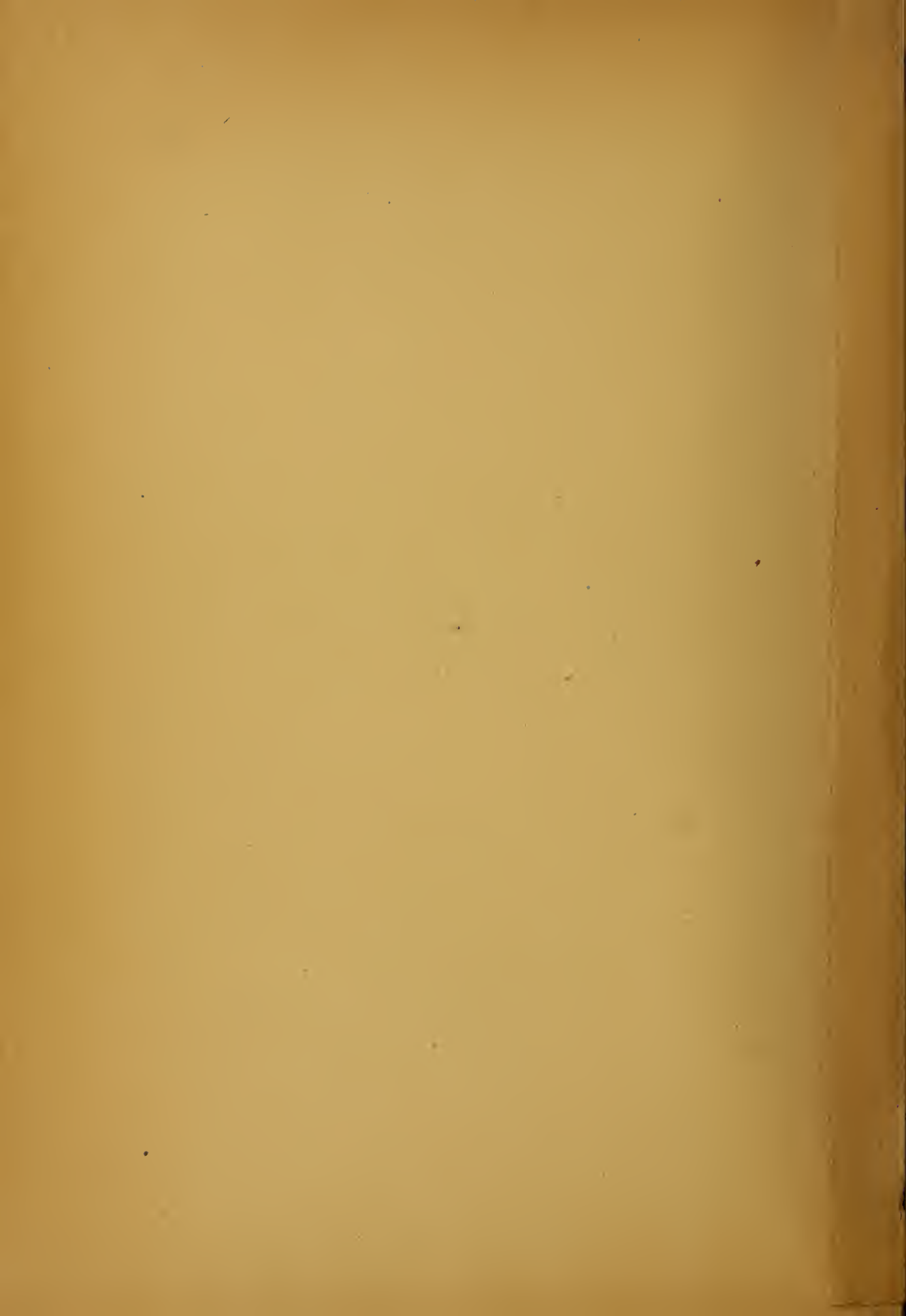


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BIOLOGICAL STUDIES OF THE BREMIDAE OF ILLINOIS

BY

THEODORE HENRY FRISON

THESIS

FOR THE

DEGREE OF BACHELOR OF ARTS

IN

ENTOMOLOGY

COLLEGE OF LIBERAL ARTS AND SCIENCES

UNIVERSITY OF ILLINOIS

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APRIL 22, 1918

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

THEODORE HENRY FRISON

ENTITLED BIOLOGICAL STUDIES OF THE EREBIDAE OF ILLINOIS.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF BACHELOR OF ARTS

IN ENTOMOLOGY.

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Introduction.

Probably no group of insects is better known to the layman than that of the bumblebees. Their large size, striking appearance and habits attract attention where other insects pass unnoticed.

Many entomologists both in the United States and Europe have devoted much time to the study of the bumblebees. In Europe work on the biology of the bumblebee has kept pace more evenly with the systematic work than in this country. Since the papers of Putnam and Packard (1864) little has been added to our biologic knowledge of the bumblebees. Systematically, however, the bumblebee group has received more attention in this country and now we have an excellent monograph of this division of the Apoidea by Dr. Henry J. Franklin (1913).

The writer became interested in these insects in 1910 and since then has devoted a great deal of time each year to their study. The present paper is intended as an introduction to the study of the biology and ecology of our native species of bumblebees. The classification of this group has been dealt with fully by Franklin (1913) and so that phase of the subject is not considered especially here. The determination, however, of the species used for study is a matter of fundamental importance, so I have introduced keys for the identification of the Illinois species of bumblebees and their bee-likeinquilines.

Acknowledgements.

I wish at this point to express my sincere thanks to Dr. Justus Watson Folsom, who first interested me in the bumblebees, accompanied me on many of my field trips, has aided me in many

ways, and under whose careful supervision this study has been carried on.

My thanks are also due to Mr. J.R. Malloch and Dr. Robert D. Glasgow who have aided the writer in securing bumblebee nests, and in other ways too numerous to mention.

The writer further wishes to thank Dr. A.D. Mac Gillivray, Dr. Edna Mosher, and Dr. Frank Smith for specimens of bumblebees, and Dr. S.A. Forbes for permission to examine the bumblebees in the collection of the Illinois Natural History Survey and the Bolter Collection as well.

PART I

Methods of Study.

It is necessary in a study of the life-history of Bremidae to resort to various methods of procedure. Descriptions of the various methods employed in such a study are valuable in that they facilitate future work along these lines, and as they are adapted to the habits of the bumblebees, indirectly tend to bring such habits into the foreground.

Situation of the Nests.

There are three main ways of obtaining bumblebee colonies. The first of these methods may be termed the locating of the nest or nests. Locating bumblebee colonies makes desirable a knowledge and study of the nest-situations. Table 1 gives a general idea of the known nest-situations of American bumblebees.

TABLE I

Species	Observer	Situation	Place.
* <u>B. ternarius</u> Say. <u>B. rufocinctus</u> Cress.	F.W.Putman.	Old mouse-nest in old stump.	Bridport, Vt.
* <u>B. ternarius</u> Say. or <u>B. rufocinctus</u> Cress.	"	Old rat-nest beneath house clapboards.	" "
<u>B. fervidus</u> Fabr. Cress.	"	Several nests in old mouse- nests under stumps, boards and among grass in nests of common field-mice.	" "
"	"	One nest in old house mouse- nest in flooring of shed.	" "
"	"	Several colonies "invariably on the surface of the ground and made as usual of dried grass."	New England States. (Probably Mass.)
"	"	In manure pile on farm.	Canton, N.Y.
"	"	In mouse-nest in rock pile.	" "
<u>B. separatus</u> Cress.	F.W.Putman	"Several colonies under old old stumps and situations similar to those in which <u>B. fervidus</u> were found."	Bridport, Vt.
"	"	Two colonies in old mouse- nests in thick grass-covered field.	Champaign, Ill.

Species	Observer	Situation	Place.
<u>B. separatus</u> Cress.	T.H.Frison (J.R.Malloch)**	Old mouse-nest in thick grass on ground beside railway track.	White Heath, Ill.
"	"	Old mouse-nest on ground in grass alongside of road.	"
"	T.H.Frison	In hollow log lying flat on ground.	Urbana, Ill. (Cottonwood)
<u>B. impatiens</u> Cress.	F.W. Putman	One nest under old stump.	Bridport, Vt.
"	H.J. Franklin	Several nests. Subterranean	Massachusetts.
<u>B. affinis</u> Cress.	"	Nest in grass on surface of the ground.	Vermont.
<u>B. bimaculatus</u> Cress.	"	One nest of grass on ground in thicket of alders.	Massachusetts.
"	T.H.Frison	In mouse-nest among leaves on ground in the woods.	Urbana, Ill. (Cottonwood)
<u>B. perplexus</u> Cress.	H.J. Franklin	Two colonies in deserted mouse-nests in walls of houses.	Vermont.
"	T.H. Frison	In mouse-nest in roof of a small shed.	Hermon, N.Y.
<u>B. vagans</u> F. Sm.	H.J. Franklin	One colony, nest "made up of dry grass....on surface of ground in an open field." In a mouse-nest.	New England States. (Probably Mass.)
"	Wm. Beutenmuller	In mouse-nest in the hollow trunk of an ash tree.	Black Mountains, North Carolina.

Species	Observer	Situation	Place
<u>B. vagans</u> F.Sm.	T.H.Frison	In mouse-nest in hollow roof joist of a high barn.	Herman, N.Y.
<u>B. emilliae</u> D.T.	Hudson	Nest in depressions on surface of ground near bushes.	La Plata, South America.
<u>B. flavifrons</u> Cress.	F.W.L.Sladen	Eighteen inches below the ground in a garden..	Agassiz, British Columbia.
<u>B. pennsylvanicus</u> DeGeer.	H. J. Franklin	Considerable number of colonies in mouse-nests on surface of the ground or subterranean.	New England States. (Probably Mass.)
"	"	About seven feet from the ground in a woodpecker's nest.	Muncie, Ill.
"	"	Old mouse-nest on ground near bush.	White Heath, Ill.
"	"	Old mouse-nest on steep bank side of railway track.	" "
"	"	Fourteen inches below ground in an old mouse-nest.	Urbana, Ill.
"	"	Under piece of over-turned sod in blackberry patch.	Champaign, Ill.
"	"	Eight inches in clay bank of railway grading, originally a mouse-nest.	White Heath, Ill.

Species	Observer	Situation	Place.
<u>B. pennsylvanicus</u> DeGeer.	T.H. Frison	In old mouse-nest alongside of railway track.	White Heath, Ill.
"	T.H. Frison (Dr. J.W.Folsom)	Old mouse-nest on ground in tall grass.	Homer, Ill.
"	T.H. Frison (J.R.Malloch)	Two colonies in old mouse-nests on surface of ground in hay field.	Urbana, Ill.
"	"	One colony in manure pile..	"
"	T.H. Frison	In an old mouse-nest in oat field.	Mahomet, Ill.
"	"	In an old mouse-nest along side of road.	"
"	T.H. Frison (J.R. Malloch)	Under eave of a small shed.	Meredosia, Ill.
"	T.H. Frison	Seven colonies in old mouse-nests on surface of ground in pasture.	Champaign, Ill.
"	"	Under an old rotten log, probably in an old mouse-nest.	Urbana, Ill. (Cottonwood)
"	L.O. Howard (C.W. Ranslow)	In English sparrow nest in a tall elm tree.	Garrison, Mo.
<u>B. auricomus</u> Robt.	T.H. Frison (Dr. J.W.Folsom)	In a mouse-nest in a cement block under cabin.	Homer, Ill.
"	T.H. Frison	In mouse-nest under the ground.	Champaign, Ill.

* Franklin says that one of the nests regarded by Putman and Packard as that of B. tern^anrius Say, is that of B. rufocinctus Cress., but as I have no means of knowing which of the situations is which, I am listing both of the two species for each situation.

** The names in brackets are those of persons who pointed out the nest to me, or else accompanied me when the nest was opened.

The species of Psithyrus do not start a colony of their own, but live as inquilines in the nests of bumblebees and hence must be looked for in such situations. There are but two published records of the occurrence of Psithyrus in the nests of bumblebees in this country. Ps. insularis Cress. was found to infest the nest of B. flavifrons Cress. by Sladen in British Columbia, and I found Ps. variabilis Cress. in the nests of several colonies of B. pennsylvanicus DeGeer. in this vicinity.

There are many other references in regard to the nest-situations of bumblebees, which because of their indefiniteness can not be considered here. From the preceding table it can be readily seen that field-mouse nests are whenever possible seized upon by bumblebee queens for the foundation of their future colony. The already-constructed, soft, dry, grass nest with its usual favorable situation is reason enough for such action on the part of the bumblebee queens. The table also shows that when a mouse-nest did not furnish the basis for the new colony, it was some closely-allied structure, as a rat's nest, wood-pecker's nest, ^{sparrow's nest,} turned-under grass sod, etc. Frequently a mouse-nest is so located that additional protection to the nest is secured, as when the nest is constructed under old stumps, logs, in house-walls, cement blocks, stone piles, etc. When a field-mouse nest so situated is selected by a queen bumblebee for her colony, the colony secures additional protection in proportion. The large number of queens which actually select mouse-nests for their colony, shows that the abundance of such mouse-nests may enter in no small way as a factor in the abundance of bumblebee colonies.

Figures 1-6 show situations where colonies have been found or

domiciles occupied by the queens. It is, furthermore, interesting to consider just what would happen if most or all of the field-mouse nests were to be destroyed. Table 1 again shows that other sites may be selected, but even then they are more or less of a ready-made nature, easily adapted by the bees to their purposes. Undoubtedly if the mouse-nests were ^{Not} found by the queens in spring, the queens would adopt substitutes, even though less suitable. Less-favored situations, especially in regard to moisture and temperature have, however, a disastrous effect on the future colony. It is an interesting speculation again to consider just what some of our species would do if no mouse-nests were available. The provided with mandibles the bumblebees seldom use them for any really strenuous work, such as excavating ^a nest in a log. Again, most of our bumblebees of which we have any knowledge show little inclination to excavate a nest in the ground. The subterranean nests of bumblebees that I have found always had as their basis a mouse-nest, and the chances are that such was the case, at least in many instances, of other reported subterranean species. In the spring, when queens are searching for nesting sites, I know of no instance in which a queen of an American species was ever discovered digging for herself a nest in the ground. It is a common occurrence in spring, however, to find many queens poking about and entering mouse-burrows in search of a favorable location. Bumblebees can dig fairly well, however, as is shown by the hibernating habits of certain European species, and in one instance by an American species (B. impatiens Cress.), as has been reported to me by Mr. C.H.W. Funaro. The time and energy taken to excavate a nest by a bumblebee queen would also be a factor in many cases in retarding an early start of the colony.

The possibilities of a queen constructing a nest of dried grass in a favorable field are greater. Here again, however, observations of any such actions on the part of the queens of the American species of bumblebees are lacking. A little grass carelessly thrown together is not enough protection for a developing colony. Grass of the right kind, ^{and} size and in sufficient quantity would take considerable time to gather and then more time to work together into any sort of a stable nest. Bumblebees are able nicely to arrange and work dried grass into shape. Thus, Sladen has reported a queen of B. agrorum (a European species) as making her nest in a ball of soft dead fibre from a bunch of pampas grass. Sladen says also that another European species, the carder-bee queen, sometimes makes the entire nest herself out of soft dead grass and moss. If a surface nest of one of our common bumblebees is disturbed, the bumblebees quickly repair the nest, but never succeed in repairing it as skillfully as it was first constructed by the mouse. Everything considered, it seems especially true of our American species whose habits I ^{that} know, bumblebee queens make the entire nest themselves only when under dire necessity of making a nest or going without one, and when conditions are exceptionally favorable for making a nest.

Mice, tho indirectly useful to the bumblebees in furnishing old nests as a basis for colonies, destroy many developing bumblebee-colonies. Sladen says that "the greatest mammalian enemies of the bumblebees are shrews and field mice. These destroy the nests before any workers have emerged." Darwin quotes Col. Newman as saying that mice were responsible for the destruction of two-thirds of the bumblebee nests all over England. It is probable that very few bumblebees actually are killed by mice, tho many a young brood is undoubtedly destroyed while the queen is away from the nest.

Bumblebee colonies have been reported as being found in an old shoe, a broken kettle, and a robin's nest by Sladen in England, which illustrates the adaptability which may be expected, and in fact is found in our American species. Many of our species seem to prefer the recesses of the woods as nesting situations, whereas, others have no hesitancy in selecting nests in the open field. From my studies it appears that ^{some} species as B. fervidus Fabr., B. separatus Cress. B. auricomus Robt., and B. pennsylvanicus DeGeer. seem content to nest almost anywhere, particularly in the open warm fields, rock piles, etc. (Figures 1-4). B. bimaculatus Cress., however, according to my observations, show a decided tendency to keep to the more cool, damp, and shady situations, such as are found in our woods. (Figures 5,6).

B. pennsylvanicus DeGeer. and B. fervidus Fabr. are the species commonly found by the farmer when working in the fields, and many such nests are annually destroyed by him. These field species of bumblebees usually have a ferocious disposition when disturbed. Horses frequently go frantic when a nest is disturbed, often resulting in many serious accidents. It is unfortunate, however, that nests are frequently destroyed, as bumblebees are so useful and indispensable in the cross-fertilization of many types of plants, of economic importance, particularly clover. Bumblebees were at one time introduced into New Zealand and Australia so as to insure the successful growing of the introduced red-clover. The habit of farmers in throwing small stones together into piles, where they are common, tends to provide bumblebees with good nesting situations and also removes the danger of necessarily disturbing them. In localities where good nesting situations are uncommon, the furnishing of such rock piles in out of way places would be a

boon to the bumblebees and indirectly yield a return to the farmer.

Moisture and temperature are factors of great importance in determining the success of a colony. Excessive moisture quickly spells ruin for a bumblebee colony, as the comb molds, causing the queen to desert. Low temperature (65°F .) retards the growth of the colony and the bees become drowsy. High temperature (100°F .) causes the comb to become sticky and soon kills the developing brood.

No special selection of the nest in regard to objects which are easily recognizable by the bumblebee queen is shown. Such objects are used as guides by the queens and later members of the colony in going and coming to the nest. Objects of striking character undoubtedly lead the queens in spring to make an examination of and about them for a place to nest.

For a general conclusion upon the subject of nest-situations it may be stated that there is in many ways an interesting ecological relation between bumblebees and mice. Moisture and temperature are important factors. Logically good situations, other conditions being equal, make for an abundance of bumblebees.

Future work upon species of bumblebees of more extreme northern and southern distribution will undoubtedly bring to light other interesting situations and resulting habits.

Locating of Nests.

The study of nest-situations naturally leads to methods employed by the student in locating nests.

The locating of nests is of less importance now than formerly on account of the possibility of using artificial domiciles and confining the queens. The main disadvantages in depending entirely upon the locating of the nests are that the colony often has progressed to

a point in development where it is of little value in a life-history study, and that the nests usually found are those of the most common species. Their value lies in the fact that they give a very good idea of the size of the "climax" colonies of the various species and throw light upon their inquiline species and parasites, besides many other little details of habits, colony arrangement and management.

It is very seldom that colonies are found very early in the spring. One way of finding colonies in spring is to watch for the queens leaving or returning to the nest. This way of finding nests takes much time and yields few results. In regard to the possibility of "lining" bumblebees, Coville says that "It was found impracticable to find the nests of the bees (bumblebees) by the method of "lining" used in the case of honey bees. It was difficult to get the bees to feed in a box. When liberated they did not fly in straight lines, and never did one return". I have never tried the "lining" method. Judging from the habits of bumblebees, I should be led to agree with Coville, admitting, however, the possibility of "lining".

A more successful way, in spring, is to find the nest directly. Of course this is usually like hunting for the traditional needle in the hay stack, but under certain conditions it may be very productive of results. A case in point may be cited of a thirty-acre tract of land near the city limits of Champaign, Illinois. The land was last used as a pasture before being laid out into city lots and the grass allowed to grow unchecked. Several years after this, in spring, before the new grass had started and the old grass was perfectly dry, a fire swept over the old pasture. The result was that the old grass was burnt off, but hundreds of mouse-nests

were left unharmed. The mouse-nests did not burn because of their compactness, which, thus far in the season, had kept them from drying out. One day after this when Dr. J.W. Folsom and myself were walking about the field, we found many of these mouse-nests occupied by bumblebee queens. A gentle tapping on the top of the nest was answered by the buzzing of a queen, if the nest was inhabited.

During the haying season and the fall many nests of bumblebees are usually found. By inquiring of farmers and friends many nests may be brought to one's attention. I have secured many nests by the information derived from a foreman who employed several men in cutting down the weeds along the sides of railway tracks.

A knowledge of the situation preferred by certain species of bumblebees is of considerable assistance in the search for their colonies.

Attracting the Queens.

Securing the nests of bumblebees by attracting the queens to artificial domiciles is a great aid in a study of the life-history of bumblebees. This method was first employed by Sladen in his excellent studies of the bumblebees of England. He devised and used several types of domiciles, each of which centered about the idea of placing of soft nest material in a protective excavation, or tin and wood domiciles. These domiciles were then buried beneath the ground, leaving unclosed a small opening for the entrance and exit of any bumblebees that might visit it. A more definite description of these domiciles and the results obtained by their use is to be found in Sladen's book. It may be mentioned, however, that with the increased protection from mice, shrews and moisture, success of a gratifying nature attended his efforts. Sladen lost colonies in

domiciles thru their destruction by ants (Lasius niger and Myrmica rubra), shrews, mice and voles, and devised means for the protection of colonies in artificial nests.

For my studies I have used domiciles of my own design. In these domiciles the general principles are the same as those of Sladen's. No special contrivances were used to keep out bumblebee-enemies, for so far I have never lost a colony once established thru such causes. Certain parasites and inquilines of all characters occasionally enter the domiciles, but have thus far caused no serious harm, and have helped me secure a better knowledge of the insects frequenting the nests of bumblebees.

The first domicile I tried was of tin. A large-size coffee can, 5" by 6", was used for the main body of the domicile. The lid of the can was provided on the top with a handle or grip. Near the bottom of the can on one side a circular hole $1 \frac{3}{8}$ " in diameter was cut. A tin spout varying in diameter from $1 \frac{3}{8}$ " at its base to 1" at its top was used as an entrance into the can. The spout was soldered against the can at the place of the opening of the can and in such a manner that the spout assumed an angle of about 35° pointing towards the top. The top of the spout was then about 3" above ^{the} can and parallel with the top of the can. Thus, when the domicile was buried in the ground a few inches, just so ^{that} the top was well covered, the spout was at the surface and level with the ground. Paint was poured down the inside of the spout and then sand or sawdust sprinkled thru the same before the paint dried; thus affording a good footing for the bumblebee. Inside the domicile was placed grass from the nest of a field mouse. A coat of paint helped to prevent the rusting of the domicile. The cost of this

type of domicile, which I shall call type A., was fifteen cents each in 1915. The chief disadvantages found with this domicile were that the lid rusted on, excessive moisture collected in the bottom of the can, and the cans were not easy to procure in numbers.

Figure 7 is a diagrammatic representation of type A.

In the spring of 1916 a new type of domicile (type B) was constructed which possessed many advantages over the former one (type A). It differed from type A in that it was provided with a removable glass top beneath the real top covering, while a smaller and better-sized tin pail formed the main body. This domicile was not so high as that of type A and consequently might have a shorter spout. The glass secondary top was a decided advantage in that the lid might be removed from the domicile without danger of the bees flying out if the nest was occupied. Furthermore, dirt did not fall into the nest when the lid was removed in order to examine the contents. A colored top glass likewise kept bright light from entering the nest and hence there was less chance of disturbing the bees. The tin pail was ^{also} vastly superior for a domicile than the coffee can, as the lid did not rust on as easily, a handle was already provided, the tin pail was more substantial, and tin pails could always be purchased. The cost of type B was thirty-five cents in 1916.

Figure 8 is a photograph of this type of domicile.

In 1917 another type of domicile, which I shall call type C, was used, and ^{the same as type B} also of type B, with certain minor improvements. Type C was made from cypress wood and was nearly square in outline. The lid was of wood and opened on hinges, beneath which was a second removable glass top, as in type B. The spout was either of tin or a piece of old rubber garden hose. The garden hose, being flexible, was especially adapted for use when the domicile was placed in a

stump or log. The cost of type C was seventy-five cents in 1917. The bottom of the box was open and screened with a very fine, strong, copper gauze. Figure 9 is a photograph of type C. Type B was used also in 1917 with the bottom removed and a piece of fine, copper gauze as in type C, soldered over the opening. The gauze bottom was an advantage in that it kept out insects and mice from the bottom of the nest, tho still providing a drain for excessive moisture. The soil beneath a domicile, if the ^{latter} is situated right, is rarely moist enough to cause trouble to the bumblebees.

All of the types of domiciles used were placed, as nearly as possible, in positions where they would be discovered by exploring queens. The domiciles should be in the ground by the time the first queens are flying.

Table **II**. gives an idea of the success I obtained by the use of domiciles.

TABLE II

Domicile Number	Type	Place	Time placed in ground.	Result	Remarks
1	A	Champaign, Ill.	April 2, 1915		
2	A	"	" "		
3	A	"	April 9, 1915		
4	A	"	April 14, 1915		
5	A	"	" "		Occupied by <u>B. pennsylvanicus</u>
6	A	"	April 19, 1915		
7	A	"	" "		
8	A	Urbana, Ill. (Cottonwood)	April 30, 1915		
9	A	"	" "		
10	B	White Heath, Ill.	April 15, 1916		Signs of occupation on June 24, 1916
11	B	"	" "		Occupied by <u>B. auricomus</u> Successful termination
12	B	"	" "		
13	C	"	April 9, 1917		Occupied
14	C	"	" "		Stolen

Domicile Number	Type	Place	Time placed in ground	Results	Remarks
15	C	White Heath, Ill.	April 9, 1917		
16	B	" "	" "		
17	C	" "	" "	Occupied	
18	C	" "	" "		
19	C	Urbana, Ill. (Cottonwoods)	April 12, 1917	Occupied by <u>B. bimaculatus</u>	Successful termination
20	C	" "	" "	Signs of occupation	
21	C	" "	" "	Occupied by <u>B. separatus</u>	Successful termination
22	C	Champaign, Ill.	April 16, 1917		
23	B	" "	" "		
24	C	Urbana, Ill. (Cottonwood)	April 17, 1917		
25	C	" "	" "	Occupied by <u>B. pennsylvanicus</u>	Successful termination
26	B	" "	" "	Occupied by <u>B. bimaculatus</u>	Successful termination
27	B	" "	April 18, 1917	Signs of occupation and desertion twice.	

TABLE III.

Table III is a summary of the main points shown by Table II.

Year	Type	Number of domiciles put out	Number known to have been inhabited	Number of desertions	Cause of dis- appearance of queen.
1915	A	9	1	1	Moisture
1916	B	3	2	1	Probably moisture
1917	B	4	2	1	Questionable (not moisture)
1917	C	11	6	3	Questionable (not moisture)
Totals		27	11	6	

Table III shows that in ~~54 1/2~~ ^{54 1/2} % of the domiciles which were known to have been inhabited, the queens disappeared for one reason or another. Moisture was responsible for the disappearance of the queens in only two instances. The other four cases where the queens disappeared may have been due to an accident to the queen while she was away from the nest, ^{the} adoption of another nest, or something else. In the domicile type B of the improved type and in type A, desertions were the result of excessive moisture.

Forty-one per cent of the domiciles placed out were occupied; the percentage of those of types B and C being 55 per cent. These figures show that if domiciles are placed out in spring, a gratifying number of them are likely to be occupied by queens. The results given above, obtained by the use of domiciles, compares favorably with those obtained by Sladen, tho bumblebees seem to be less abundant here than in England.

Confining the Queens.

Another way of obtaining colonies of bumblebees at their very inception, is by confining the queens. Sladen tried confining single queens and found that occasionally a queen would lay eggs, which in some instances hatched, but then deserted the nest. Later Sladen confined two queens together instead of one, and had more successful results. However, about the time the first eggs were laid, or shortly after, one of the queens usually killed her companion and then finally deserted the nest. If two or more workers, usually of the same species, were supplied to the queens in confinement, the colony was often successfully reared.

Of my own experiments in confining the queens I shall consider only those of the years 1915, 1916 and 1917; as my experiments

previous to those years were too poorly conducted. It was not until 1917, when two queens were used in each box, that I succeeded in getting colonies by this method.

Queens for confining may be captured at any time in spring, before they have started colonies, and safely brought to the study-room in large-sized mailing tubes.

For confining the queens I used in 1917 a small wooden-box 5" by 7" by $2\frac{1}{2}$ ". At one end of the box was a round opening which could be closed by the insertion of a cork. The top was of small glass sections, sometimes of ruby or amber colored glass. A dark cloth was wrapped about the box to exclude light. In the box was placed fine, soft grass from a mouse nest, and within the grass nest a fresh lump of honey-bee pollen. In a far corner of the box was placed a small tin, in which was kept food consisting of a mixture of honey, rye-flour and water. Some variations of the above method were employed, as for instance the use of a piece of sod with the mouse-nest on it intact in a larger box. In one place workers were supplied with a queen, but only after she had the colony well under way. Table IV gives the results obtained by confining the queens. The experiments of confining queens of 1917 were the only experiments performed with all the conditions as described above, and hence, they are the ones really to be seriously considered.

TABLE IV

Species	Box number	Number of queens & workers.	Date experiment started	Result	Remarks
<u>B. impatiens</u> Cress.	1	1 queen	4-30-1915	Queen died 5-25-1915	Before queen died she had patted grass down nice and "cozy-like" as tho starting nest
<u>B. bimaculatus</u> Cress.					
<u>B. auricomus</u> Robt.	2	1 queen	4-30-1915	Queen dead 6-23-1915	
<u>B. pennsylvanicus</u> DeGeer.	3	1 queen	4-30-1915	Queen dead 5-5-1915	
<u>B. impatiens</u> Cress.	4	1 queen 3 workers	5-25-1915	Queen Dead 6-1-1915	Interest taken in the nest at first, especially by workers
<u>B. pennsylvanicus</u> DeGeer.	5	1 queen	4-23-1915	Queen dead 4-30-1915	
<u>B. impatiens</u> Cress.	6	1 queen	4-23-1915	Queen dead 5-2-1915	
<u>B. impatiens</u> Cress.	7	1 queen	5-5-1916	Queen dead 5-7-1916	
<u>B. separatus</u> Cress.	8	1 queen	5-5-1916	Queen dead 5-27-1916	
<u>B. bimaculatus</u> Cress.	9	2 queens	4-17-1917	Colony successfully started and continued thru	

Species	Box number	Number of queens & workers	Date experiment started	Result	Remarks.
<u>B. bimaculatus</u> Cress.	10	2 queens	4-17-1917	1 queen dead 5-1-1917 1 queen dead 5-10-1917	Interest manifested in nest, but no eggs or cells
"	11	2 queens	4-19-1917	Colony successfully started and carried thru	
"	12	2 queens	4-20-1917	1 queen dead 5-9-1917 1 queen dead 5-16-1917	Interest manifested in nest, but no eggs or cells.
"	13	2 queens	4-20-1917	1 queen dead 4-23-1917 1 queen released	
<u>B. separatus</u> Cress.	14	2 queens	4-23-1917	1 queen dead 5-13-1917 1 queen dead 5-24-1917	
<u>B. pennsylvanicus</u> DeGeer	15	2 queens	5-15-1917	1 queen dead 5-23-1917 1 queen released	
"	16	2 queens	6-21-1917	1 queen dead 7-5-1917 1 queen released	
<u>B. auricomus</u> Robt.	17	2 queens	5-14-1917	Colony successfully started and carried thru	

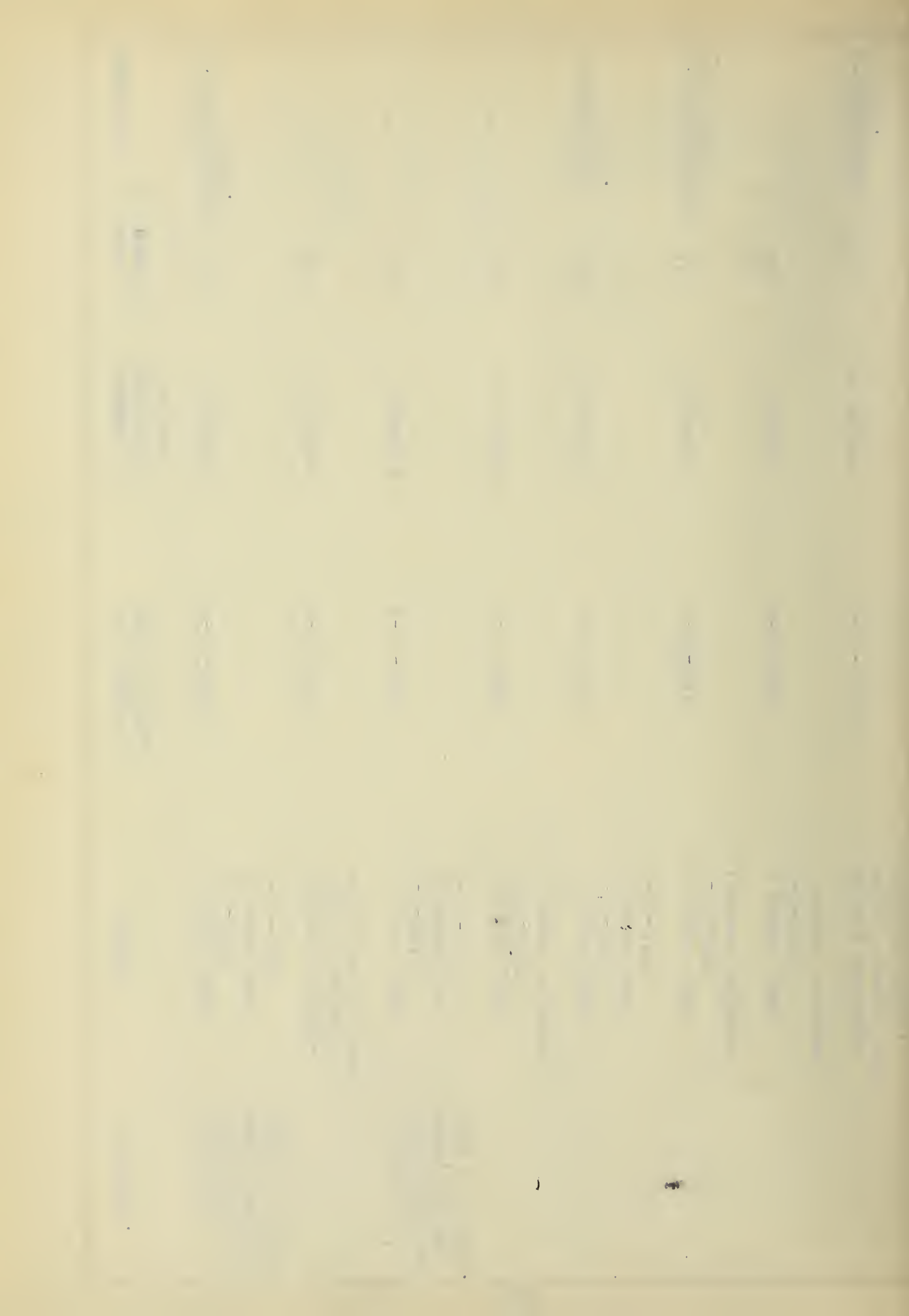


Table IV shows that the placing of two queens in a nest is more productive of results than the placing of a single queen in the nest. In fact, I never secured a colony by confining a single queen, tho the apparatus, feeding and so forth of these earlier experiments may have been the cause. Considering the experiments of 1917 separately, three out of nine experiments produced successful colonies. In two others a decided interest was shown by the queens, which did not, however, lay eggs.

Summarizing then: colonies may be obtained by confining the queens in sufficient numbers, at the very beginning of the active season.

Removal of the Nests.

In removing a nest of natural origin one must be careful to avoid getting the comb dirty, injuring the brood, or getting stung. About dusk is the best time to remove a colony for purposes of study. If the colony is a surface nest, individual vicious workers may be caught in a net, after the nest is slightly jarred, and then put into jars. After this, a little of the grass covering may be removed, and a cotton wad saturated with ether or chloroform forced down upon the top of the colony. After several minutes, when the buzzing has somewhat abated, the nest may be removed without much danger of being stung. If the nest is beneath the surface of the ground the entrance may be blocked with ^{an} ether-or chloroform-soaked wad, and the nest then dug out. It is hard to avoid getting earth on the comb of a subterranean nest and patience in digging the nest out is necessary. Care must be exercised as to the quantity of anesthetic used, or the bees and brood may be killed. Colonies are often destroyed by boys and farmers who "beat" them out. The use of

a water-jug in exterminating a colony has been described at length by Marlatt. (Proc. Ent. Soc. Wash., Vol. 1, p. 216.)

In removing a domicile containing a nest of bumblebees, one only needs to wait until evening to close the spout with cotton batting and remove the domicile.

Observation Boxes for Colonies.

For the final housing of colonies of bumblebees various devices have been used. Sladen devised and used a "Humble-bee House", which was capable of accommodating several colonies besides having other attractive advantages. For my own work, however, I have always used single individual boxes. A box containing a colony may be placed along the side wall of a shed, barn or other building, providing a hole leading to the nest is made in the wall of the structure.

The observation boxes that I use are 8" by 5" by 4" and are made of wood. Both ends and the top are of sectional glass strips. On one side is an opening, which may be closed at will. When in use I keep the boxes covered with dark cloths. While not so complicated as those of Sladen, these boxes answer their purpose, are rather inexpensive (85 cents in 1916) and can be easily moved about. Figure 10 is an illustration of this type of box.

I usually place in the observation box a considerable amount of soft, dried grass, before a nest is put in it. After a nest is transferred to one of these boxes, the opening to the nest should be kept closed for a couple of days before releasing the colony. I always place a small tin in one corner of the nest, in which I supply the food to the bees for the first few days.

Each egg is given a number as soon as it is discovered. In cases where the queen lays her eggs in batches, I reserve a number for each egg of the batch ^{when} and the exact positions of the larvae are discernible, I assign to each ~~to each~~ one of the larvae one of the reserved numbers. Constant diagrammatic drawings of the comb, showing the various positions of the cells, must be made in order to keep an exact record of the growth of the comb. The comb is constantly changing in size and form, so that to rely upon the memory for the exact position of each cell (there may be over three hundred) is out of the question. With such a system as the preceding an accurate record of each individual of the colony, except the original queen, may be kept from the egg to the adult stage.

PART II

Fertilization and Hibernation Experiments.

General Account.

Before describing my efforts to obtain the fertilization and hibernation of bumblebee queens, I will review what is already known in regard to the subject.

It is a well known fact that bumblebee queens hibernate. Little is known, however, as to where our own species hibernate or as to the conditions and the causes of hibernation. The fact that bumblebee queens are produced in summer or fall, disappear and then reappear in spring indicates a period of hibernation thruout the cold months. Again, bumblebee queens are occasionally found in their winter quarters, concerning which almost nothing has been published. The same evidence of a state of hibernation holds equally well for Psithyrus queens. One winter I found a hibernating queen of Psithyrus in an old stump, and Mr. H.G.M. Crawford brought me a queen of B. separatus which he had found hibernating in an old log. Mr. James Zetek found a cluster of six queens of Ps. variabilis about six inches below the surface of the ground in the leaf-mold beneath a log in the timber near Urbana, Illinois. Mr. C.H.W. Funaro found over two hundred queens of B. impatiens digging their way out of a sand-bank in the early spring near New York City.

The view is held that the queens are fertilized in the fall by the males before the winter months set in. Here again the evidence shows that such is the case. The males emerge at about the same time as the queens, and soon disappear. As no males are found in spring it is supposed that the males die when winter

approaches, and such is the case. The only possible time for fertilization of the bumblebee queens is, therefore, in the summer or fall. Fairchild and Barrett (1906) have reported a case of the copulation of B. fervidus in the fall. I am inclined to think, however, that the species was really B. pennsylvanicus. I have been able to secure the copulation of many males and queens in the fall under controlled conditions.

Contrary to common opinion, copulation and hibernation may take place much earlier than in the fall. In the case of B. bimaculatus the males and queens are flying in July, and by the last of August both sexes have disappeared in this vicinity. Experiments which I will give later show that the fertilization of the queens ^{of this species} takes place before the last of August. After being fertilized the queens go into a state of hibernation — in this species aestivation — a long time before cold weather actually sets in. B. bimaculatus is an example of a bumblebee which goes into a resting state without the stimulus of winter. The queens of most of the other common species, as B. pennsylvanicus, are still to be found active in late September and early October. In the laboratory where it is warm, many queens are still active in November, but soon after this die.

Naturally bumblebee queens are fertilized by the males away ^{the} from ^{that} nest; at least this is the case in the species I know. The males may remain in or about the nests for a week or more after emerging, but after that they usually desert the nest for good. The males of B. pennsylvanicus frequently sit about on the top of a surface nest during the warm part of the day, darting up now and then, as if waiting for a queen to leave the nest. The males of

the species with large, bulging eyes, as B. separatus, are fond of sitting and hovering about conspicuous objects. The males of some species fly along a roadside fence, each in turn stopping at some particular object, as if following the scent of a previously passing queen. The males of B. bimaculatus, where they are common, veritably "stream" by and around objects scented by some passing queen. By placing out a queen of B. bimaculatus in a bottle, the end of which was covered with cheese-cloth, the males would come to the bottle in large numbers.

Copulation, I am inclined to believe, rarely takes place within the nest under natural conditions. In confined colonies, however, males and queens frequently copulate.

In bumblebees I doubt if there is any "nuptial flight" comparable to that of the honey bee. The male and queen in coitu observed by Fairchild and Barrett were clinging to a young cherry tree about six inches high.

Fertilization Experiments.

During the last two years in connection with hibernation experiments I tried to secure the fertilization of the Bremus queens.

Reared queens were placed in glass jars, the bottom of the jars being covered with corrugated paper. A bumblebee cocoon fastened in the middle on the bottom of the jar, served as a container for the liquid food supplied to the bees, the food consisting of a mixture of strained honey and water. The top of the jar was tightly covered over with cheese-cloth. When the fertilization of the confined queen was desired, one or more males of the same species were introduced into the jar. The males were either rear-

ed or secured from flowers along the country roadside.

In many cases fertilization was accomplished by the use of the above method. If a male was indifferent to the queen the shifting of a male from one jar to another often had the desired effect. The presence of two or more males usually was a stimulus to copulation on the part of one or more of the males. Copulation takes place during the warmest part of the day, so I am fairly safe in assuming that in those cases in which copulation was never observed during the day, it did not occur during the night. Towards evening and early in the morning the queens and males were sluggish.

In 1916, in 29 jars (B. pennsylvanicus) in which males were allowed access to the queens, copulation was attempted in 20 cases, and actual union of the genital organs ^{was} observed in 10 instances. In only one case was copulation even noticed as being attempted in the 11 Ps. variabilis jars. The above figures show that I succeeded in securing ^{fertilization} the ^{of} at least 30% of the queens of B. pennsylvanicus in 1916.

In the summer and fall of 1917 still better results were obtained by confining the males and queens. The fertilization of the queens of B. bimaculatus was secured both by tying out the queens and ^{by} confining them with drones. The experiments with the males and queens of B. bimaculatus were performed during the early part of July, illustrating how early copulation takes place in this species. During the middle of September many experiments were conducted with the males and queens of B. pennsylvanicus. Of a total of 28 reared queens of this species, from one nest, the fertilization of nearly 100% was secured. During these experiments with B. pennsylvanicus 37 males, reared from the same colony as the queens, were used. Only 3 males were killed by the queens.

Some pairs of males and queens were in coitu at least four hours. Three reared queens of B. auricomus were likewise confined with males in the fall of 1917, but in no case was copulation even attempted. This may be due to a peculiarity in the copulation habits of this species.

In view of the above statements it is safe to say that the fertilization of the queens of some of the species of bumblebees may be obtained with gratifying results under controlled conditions. Complete domestication of the bumblebee is therefore attainable.

Hibernation Experiments.

A successful artificial hibernation of a bumblebee queen thus far has proved a difficult task. Mr. Warren Williamson in 1910 attempted to hibernate a large number of B. pennsylvanicus queens, but they all died. One of these queens, however, still manifested weak signs of life on the first of April, tho never reviving. Sladen kept one queen until the eighteenth of September.

For several years preceding 1916 and 1917 I attempted to hibernate bumblebee queens. Queens were secured from any possible source, placed in small boxes with leaves, and put in cold situations. Frequently over fifty queens were used in these early experiments, but all of them died before December of the same year. These repeated failures led to the fertilization experiments, and hence a sounder position from which to carry on hibernation experiments.

Experiments of 1916.

In the fall of 1916 I began experimenting with 40 B. pennsylvanicus and 20 Ps. variabilis queens. Besides trying to secure the fertilization of the queens, more attention was paid to the hibernating quarters, and the conditions leading to hibernation. The queens, after having access to the drones, were placed in the separate jars for several days and allowed to feed up on honey. Then some evening a little cooler than usual, I placed the queens out of doors, and in the morning they were quite sluggish. Then I placed the queens in cans containing earth or dried leaves, and put the can^s either in cold storage or in the ground. None of the queens used in the experiments of the fall of 1916 survived the winter. The moldy condition of the queens seemed to be an indication of excessive moisture.

The death rate of the queens in 1916 is of interest because of the possibility of its close relation to the question as to whether or not unfertilized queens can survive the winter. In my notes on fertilization experiments I always divide my observations under the four following headings:

- (a) Copulation actually observed.
- (b) Copulation attempted.
- (c) No indication of copulation.
- (d) No possibility of copulation. (males absent).

Some of the queens under the second heading (b) may have been fertilized, but I am satisfied that none in ^{the} third group (c) were. Table V gives the number of queens used in the experiments of this nature, the number which died, and also the number alive at the time I was ready to transfer them to winter quarters.

Table V

Group	Original number	Number alive	Number dead
A	10	9	1
B	10	7	3
C	8	5	3
D	7	2	5
Totals	35	23	12

Table V is thus indicative of the fact that the fertilized queens possess the greatest vitality, and hence are the ones most likely to survive the critical season; the unfertilized queens dying.

As I could not secure the fertilization of the 20 Psithyrus variabilis queens used in 1916, I can not give a comparative death-rate table for them as for Bremus. It may be stated, however, that all of the Psithyrus queens soon died.

Experiments for 1917-1918.

In the summer and fall of 1917 I again undertook to hibernate reared queens of B. pennsylvanicus and B. bimaculatus.

The queens of B. bimaculatus emerging in July were first used. Six queens of this series were confined with the males as in the experiments of 1916, and then several days later were placed in cans containing earth ^{in cold} storage. These queens were all dead and moldy on February 8, 1918.

I used 3 queens of B. auricomus and 19 queens of B. pennsylvanicus in my experiments in the fall of 1917. As stated before, the pennsylvanicus queens were fertilized but the auricomus queens

were not. Table VI shows the methods used to hibernate these queens.

Table VI

Species	Number of queens.	Hibernation quarters	Situation	Results
<u>B. auricomus</u>	3	In can with earth.	Cold storage warehouse.	Died in the fall.
<u>B. pennsylvanicus</u>	10	In small jelly-glasses containing earth; the lids being perforated.	Buried one foot beneath the ground in woods.	Dead and moldy by December.
"	4	In small perforated cans, containing earth.	Three buried in the ground and one placed in tree trunk in woods.	" "
"	1	In perforated mailing-tubes, placed in perforated can, containing earth.	Buried six inches beneath surface in garden.	Dead in March 1918. Moldy. Soil in can wet.
"	4	In perforated mailing-tubes, which were in turn placed in quart fruit jars, the lids of which were perforated. No earth or leaves in tubes or jars.	Buried six inches beneath surface in garden.	All queens survive in perfect condition.

Table VI shows that the successful hibernation of B. pennsylvanicus queens was accomplished in 1917-18. Table VI likewise shows that excessive moisture was probably the cause of the failure in the less successful experiments. The queens which survived the winter in perfect condition were in quarters where they were not in contact with damp earth or leaves. The perfect hibernation of these four queens points the way to future successful hibernations and is the removal of the last obstacle in the domestication of the bumblebee.

It is interesting to note that within one half hour after I removed the queens from the ground, they were walking about in quite a lively manner and within an hour were flying against my study window. The revived queens were not observed to feed until the second day.

Hybridism.

Nothing has been done towards the crossing of different species of bumblebees. From my observations I do not doubt that males of one species would try to copulate with queens of another species. In one of my experiment jars I observed a male of B. pennsylvanicus try to copulate with a Psithyrus queen, but without success.

One difficulty in the way of crossing different bumblebee species lies in the habits of the queen. Frequently a queen will kill a drone of her own species; partiality seeming to be shown to males of the same colony as the queen. When queens will kill males of their own species it is likely that they will be less tolerant still of the males of different species.

Structural features of the genitalia of various species are

undoubtedly another limiting factor of crossing. Finally, even if actual union of the genital organs of two different species occurred, would one be safe in saying fertilization actually occurred? The main proof of a successful experiment in hybridization would be seen in the hibernation and the development of a hybrid colony by the queen.

Conclusion.

During the course of these experiments only three species of bumblebees have been available for study. Undoubtedly, however, the majority of the species of bumblebees can be studied in the same manner as the three species discussed in this paper.

All the conditions necessary to a complete domestication of the bumblebee have been fulfilled; such as getting the queens under confinement to start and develop normal colonies, and securing the fertilization and hibernation of the reared queens.

The employment of such methods as are described in this article will furnish the means for further studies of the complex phenomena of bumblebee-life. It is the purpose of the writer to work out in the future a biologic comparison of all our bumblebees.

PART III

Distribution.

General Discussion.

Almost everyone interested in the biological sciences has been at some time or other confronted with the question, where did this or that group of animals or plants originate; and many other similar questions as well. It is clearly advisable, before one attempts to explain the distribution of a certain group, to know the great majority of the species of that group and their habitats. The appearance of Dr. H. J. Franklin's (1913) extensive monograph of the American Bremidae has furnished the basis for a recent paper by Dr. Frank E. Lutz (1916) on the geographic distribution of this group.

Dr. Lutz accepts the opinion of Friese (1900) and others that the bumblebees originated from a Euglossa-Hemisia complex. Dr. Lutz also believes that the Bremidae originated in the northern regions and that their dispersal has been southward. In support of this southward migration Dr. Lutz advances various arguments based on past geologic history, fossil indications, and the present distribution of the so-called recent and old forms. The members of the Fraternus and Dumoucheli groups are regarded as being our most primitive groups. These groups reach their greatest abundance south of the United States. Their present distribution is explained by Lutz on the ground that these species are the vanguard of the migration wave, and were either driven from the north by the change from a warm to a colder climate, or by the competition with new forms. The other groups of Franklin and Radoszkowski are given intermediate positions in the migration

wave; the Terrestris group being considered as of recent origin.

The writer believes that thoro life-history work will throw much light upon the phylogeny of the bumblebees, and indirectly upon faunal dispersal in general. The present distribution of our groups of Bremidae, providing the groups as we know them are homogeneous, is certainly indicative of migration.

The distribution of the Illinois species of the family is interesting, in that Illinois represents what one might term an intermediate position. Illinois is intermediate between those states possessing the largest and those with the smallest number of species. Many western states, with their diverse geographical features have listed nearly twenty-five species of this family, and I believe the lists will be considerably increased in the future. Florida is accredited with only four species, and all of the Gulf states appear to have a paucity of species. The writer has increased the Illinois list from ten to fifteen species of Bremidae, and believes the list will in time be swelled to twenty species.

Distribution of Psithyrus.

The distribution of the species of Psithyrus depends almost entirely upon the distribution of the species of Bremus whose nests they infest. In Illinois I have shown that Ps. variabilis infests the nests of B. pennsylvanicus (1916). Ps. variabilis is therefore to be expected wherever B. pennsylvanicus occurs, other conditions being the same. It is not known in this country whether the same species of Psithyrus is an inquiline in nests of more than one species of Bremus or not. Sladen (1915) found Ps. insularis in the nest of B. flavifrons. Ps. insularis is, however, listed from

regions where B. flavifrons is not known and is not even likely to occur; indicating that Ps. insularis must be an inquiline in the nest of more than one species of Bremus. The distribution of Ps. laboriosus in this and other states has impressed the writer with the belief that it is an inquiline in the nests of B. fervidus or B. vagans.

Groups of Bremidae.

Of the ten groups of Bremidae erected by Franklin and Radoszkowski; Illinois has representatives of eight of them as follows:

Bremus

Terrestris Group Rad.

terricola Kirby.

*affinis Cress.

Borealis Group Frank.

borealis Kirby

Pratorum Group Rad.

bimaculatus Cress.

impatiens Cress.

vagans F. Sm.

frigidus F. Sm.

*ternarius Say.

perplexus Cress.

Dumoucheli Group Frank.

pennsylvanicus DeGeer.

fervidus Fabr.

Auricomus Group Frank.

auricomus Robt.

nevadensis Cress.

Fraternus Group Frank.

fraternus F. Sm.

separatus Cress.

* rufocinctus Cress.

Psithyrus

Laboriosus Group Frank.

laboriosus Fabr.

variabilis Cress.

* insularis F. Sm.

Ashtoni Group Frank.

* ashtoni Cress.

* The species starred have not as yet been taken in this state, but will probably be captured eventually in the northern part of the state.

Five species of Bremus (terricola, frigidus, nevadensis, borealis, and perplexus) are here listed for Illinois for the first time. Maps showing the distribution in the United States are given for only those species which are actually represented by specimens from Illinois bearing definite locality labels.

Discussion of the Groups.

A discussion of the various groups of Bremidae and of the Illinois species belonging to them follows. The life zones of Merriam (1898) are the ones used in this paper.

Terrestris Group.

One species (B. terricola) of this group is represented by

Received of the
Hon. Secy. of the Navy
the sum of \$1000.00
for the purchase of
the ship "Albatross"
on the 1st day of
January 1882
at New York
this 1st day of
January 1882
at New York

The sum of \$1000.00
being the amount of the
purchase money of the ship
"Albatross" on the 1st day
of January 1882 at New York

Witness my hand and seal
this 1st day of January 1882
at New York
John D. Long
Secretary of the Navy

John D. Long
Secretary of the Navy
New York
1st day of January 1882

specimens from Illinois, and another species (P. affinis) will probably be found in the north part of the state, as it occurs in Wisconsin. The specimens of P. terricola in the collection of the Illinois Natural History Survey are from Algonquin, Illinois, and the species is to be expected thruout the northern part of the state.

Figure 10 shows the approximate distribution of P. terricola.

P. terricola occurs mainly in the Eastern Boreal and Transition zones, running over somewhat into the Upper Austral zone.

Borealis Group.

P. borealis is the only representative of this group occurring or likely to be found in Illinois. P. borealis is most commonly met with in the Boreal and Transition zones, overlapping southward somewhat into the Austral zone as in Illinois. There are several specimens of this species taken by Mr. J.R. Falloch and the writer in August, 1917, at Waukegan, Illinois.

Figure 11 gives approximately the distribution of this species.

Pratorum Group

The Pratorum Group is the largest group of the American Brenidae and Illinois contains more species of this than of any other group. The Illinois species range from species heretofore considered as strictly boreal forms, as P. frigidus, to forms as P. impatiens, which are found in Florida.

Previously only three species of this group (P. bimaculatus, P. impatiens and P. vagans) were listed from this state.

B. frigidus and B. perplexus have been added to this list and P. ternarius undoubtedly will be added sooner or later. Perhaps the most striking record of the distribution of bumblebees in Illinois is found in the occurrence of B. frigidus. The Illinois specimens of B. frigidus in the Illinois Natural History Survey Collection are from the collection of Mr. O. S. Westcott. In a list of the species of Eremidae in the Westcott Collection, sent me by Mr. Westcott, B. frigidus and B. perplexus were listed from Maywood, Cook County, Illinois. The listing of B. perplexus from Northern Illinois is nothing more than I should expect; as this species is found in Wisconsin and Minnesota. B. frigidus, however, is thought to be strictly a Boreal form, and has as yet never been reported from Wisconsin, Minnesota or Michigan, states more northern than Illinois. However, as the specimens of B. frigidus in the Illinois Natural History Survey Collection bear an Illinois label, they must be accepted as Illinois specimens, unless it be shown that there was a mistake in the labeling, which is doubtful.

B. bimaculatus and B. impatiens occur mainly in the eastern part of the Transition and Upper and Lower Austral zones. B. vagans is found mainly in the Eastern Boreal, Transition and Upper Austral zones extending considerably westward, however, in the northern part of its' range. B. vagans is more common in the northern part of Illinois, than in the southern or middle sections. B. bimaculatus and B. impatiens are common thruout Illinois.

Figures 12,13,14,15, and 16 show, respectively, the approximate known distribution of B. bimaculatus, B. impatiens, B. vagans, B. perplexus, and B. frigidus, of which we have Illinois records.

Dumoucheli Group.

Illinois has two members of this group within her borders.

B. pennsylvanicus is common thruout the most of the state, especially so in the southern and middle portions. B. fervidus is more abundant in the northern part. The same tendency of B. fervidus toward^a more northerly range is shown in the occurrence of this species in the United States in general. Both species appear at their maximum in the Transition and Austral zones. B. fervidus has, so far as known, the most extensive distribution thruout the United States of all the bumblebees occurring in Illinois. B. pennsylvanicus, is also a very cosmopolitan species.

Figures 17 and 18 show the approximate distribution of B. pennsylvanicus and B. fervidus, respectively.

Auricomus Group.

Of this group B. auricomus is found in all parts of Illinois, and there is a single specimen of a queen of B. nevadensis from Illinois in the Folter Collection. The record of B. nevadensis is interesting in that this species has not been previously reported further west than Nebraska (Swenk, 1907). Both species are found mainly in the Transition and Upper Austral zones, B. nevadensis being the more Boreal of the two.

Figure 19 shows the approximate distribution of B. auricomus. No map for B. nevadensis is given, as the specimen in question bears no locality label, except that of Illinois. Probably, however, the specimens came from the northern part of this state.

Fraternus Group.

Two species of this group occur in Illinois and a third may be expected. B. separatus, found everywhere in this state, occurs chiefly in the Upper and Lower Austral and Transition zones.

B. fraternus is more strictly confined to the Austral zones, and especially the Lower Austral zone. In this state it has always been a source of wonder to the writer ~~why~~^{how} one could collect specimens of the B. fraternus almost any summer day fifty miles south of Champaign, and yet at Champaign almost never encounter one.

B. rufocinctus is likely to be found in the northern part of the state, as it is more of a Transition and Boreal species than either B. separatus or B. fraternus. B. rufocinctus is comparatively a very variable and cosmopolitan species. Next to B. fervidus, B. separatus has the widest distribution in the United States of the species of bumblebees occurring in Illinois.

Figures 20 and 21 show the approximate distribution of B. separatus and B. fraternus respectively.

Laboriosus Group.

Two species, Ps. laboriosus and Ps. variabilis, are known to occur in Illinois, and Ps. insularis may eventually be captured within our boundaries. Ps. variabilis, as stated before, may be expected wherever B. pennsylvanicus occurs; hence in the Transition and Upper and Lower Austral zones. Ps. laboriosus is more of a northern species, ranging somewhat into the Boreal zone. Ps. insularis is a Boreal and Transition species and may eventually be taken in the northern part of this state.

Figures 22 and 23 show the approximate distribution of Ps. laboriosus and Ps. variabilis respectively.

Ashtoni Group.

Ps. ashtoni is the only species of this group likely to be found in Illinois. It is considered to be mainly a species of the

Transition zone, overlapping into both the Boreal and Upper Austral zones. Nothing is known concerning its inquiline habits.

Summary.

Briefly, fifteen species of Eremidae have been taken in Illinois, and five other species may be captured later. Eight of the ten present American Groups are represented in this state. The Illinois species of Eremidae range from Lower Austral to Boreal forms. The majority of the species are principally forms that reach their present greatest abundance in the Transition and Upper Austral zones.

PART IV

Classification of Bremidae.

The following five keys will serve for the separation of the males, queens, and workers of ~~the~~ sixteen species of Bremus, and of the males and queens of four species of Psithyrus. These keys are not intended to represent the writer's views of our Bremidae phylogenetically, but are simply for the purpose of an easy identification of the Illinois species. Characters evident to the naked eye are used in the keys wherever possible, in preference to those of more obscure nature.

It has been found necessary to replace the name of Bombidae by that of Bremidae for the following reasons. The genus Bombus was first proposed for the bumblebees by Latreille in 1802. In 1805 Bremus was used by Panzer for this same group. Quite naturally, then, the term Bombus was at first accepted as having priority over Bremus. Panzer, however, writing in 1805 referred to an article by himself that was published earlier than 1805. A recent investigation has disclosed, in the library of the University of Erlangen, an article now known as the "Erlangen List". This list was published, unsigned by Panzer, its author, in May 1801 and contained a synoptic list of the Panzer-Jurine Genera compared with the genera adopted by Latreille. In this list we find Bremus first used as the name for the bumblebee division of the Apidae. The discovery of this article naturally gives Bremus (1801) priority over Bombus (1802), and also explains the use of Bremus by Panzer in 1805. Bremus, however, must not be accredited to Panzer, but to Jurine. It was Jurine, then living in Bern, Switzerland, who had first worked out the so-called "alary system", and had sent

specimens and particulars of their "habitates" to Panzer in 1779. Panzer writing in 1801 merely published in an expanded form the names, figures, and information sent him by Jurine. It is Jurine then, who is responsible for Bremus and for certain other genera not discussed in this paper. Bremus included both the true bumblebees and their bee-like inquillines; hence the name Psithyrus of Lepeletier (1832) for these bee-like inquillines still stands.

The writer has deemed it best, at least for the present, to follow Franklin and regard Bombias of Robertson (1903) as a subgenus instead of as a distinct genus. There are these two reasons for this attitude. First, the following keys are for the identification of the Illinois species of Bremus, and only represent a study of sixteen of the forty-seven species of Bremus listed by Franklin from North America; and the adoption of the use of a generic name should be based upon a study of a group as a whole and not upon a few species from a particular locality, however well these species seem to fit into a separate genus. Second, the writer agrees with Franklin, that the Bombias division in reality contains two distinct subdivisions. Only a careful study of the life-history of the bumblebee species seems to present a possible future solution of this question.

In a recent article it has already been shown that the life-history of B. (Bombias) auricomus Robt. differs widely from that of any other true Bremus with which I am familiar. It is thought best, however, at this time to wait until more work has been done on the life-histories of our American bumblebees, before using such evidence as an aid towards a natural grouping of the Bremidae.

Because of the variation in the color of the pubescence of certain species of Bremidae, it has been found necessary to put

such variable species in the keys in more than one place. There are several varieties of B. rufocinctus Cress. that have not been included in the keys, as they have been reported only from the Rocky Mountain Region.

The males of the two genera of Bremidae may be readily separated from each other by the fact that the volsella and the squama of the genitalia of Psithyrus are membranous, whereas in Bremus they are corneous.

The outer surfaces of the hind tibiae are usually more or less covered with hairs in the males of Psithyrus, and in Bremus rather bare.

In females, the outer surfaces of the hind tibiae of Psithyrus are more covered with hairs and rounded, while those of Bremus are more bare and flattened. In Psithyrus there are no workers.

Key for the Separation of the Males of the Genus

Bremus from Illinois.

1. Eyes large and bulging out from the sides of the head; ocelli large and placed well below the supra-orbital line (Bremus, subgn. Bombias) -----2.
- Eyes normal, not bulging out from the sides of the head; ocelli small, placed near supra-orbital line, and above the narrow^{est} part of the vertex (Bremus) -----6.
2. Third antennal segment as long as the fourth and fifth segments taken together-----3.
- Third antennal segment not as long as the fourth and fifth segments taken together-----4.
3. Sixth and seventh dorsal abdominal segments usually with ferruginous pubescence----- nevadensis Cress.
- Sixth and seventh dorsal abdominal segments black-----
auricomus Robt.
4. Second dorsal abdominal segment with its basal middle covered with a tawny or dirty yellow pubescence, the remainder of the segment being black----- separatus Cress.
- Second dorsal abdominal segment not so colored-----5.
5. First two dorsal abdominal segments with yellow pubescence, the remaining segments black; eyes greatly swollen and bulging out from the sides of the head; malar space a mere line.-----
-----fraternus F. Sm.
- Last five dorsal abdominal segments usually with other than black pubescence; eyes some what swollen and bulging out from sides of the head; malar space about one-half as long as its width at lower margin or apex-----

rufocinctus Cress.

6. Fourth to seventh dorsal abdominal segments with black
pubescence dominating-----7.

— Fourth to seventh dorsal abdominal segments not so colored
-----10.

7. First dorsal abdominal segment yellow, remaining segments
black-----impatiens Cress.

— Dorsal abdominal segments not so colored-----8.

8. First two dorsal abdominal segments entirely yellow-----
vagans F. Sm.

— First two dorsal abdominal segments not entirely yellow-----
-----9.

9. First dorsal abdominal segment, and at least the basal middle
portion of the second segment, yellow-----
bimaculatus Cress.

— First dorsal abdominal segment yellow; second segment with
sides and apical margin yellow, the remainder having a
tawny or dull ferruginous pubescence-----affinis Cress.

10. First dorsal abdominal segment, except for a very few light
colored hairs, black-----terricola Kirby.

— First dorsal abdominal segment not so colored-----11.

11. Third dorsal abdominal segment black---- frigidus F. Sm.

— Third dorsal abdominal segment not so colored-----12.

12. Second and third dorsal abdominal segments ferruginous-----
-----ternarius Say .

— Second and third dorsal abdominal segments not so colored---
-----13.

13. Dorsum of the thorax covered, except for a few occasional
black hairs upon the disk, with yellow pubescence-----

- 14.
- Dorsum of the thorax with more or less of a decided black band between the bases of the wings-----15.
14. Third antennal segment as long as the fifth; occiput usually with yellow hairs dominating; malar space about as long as its width at apex; dorsal abdominal segments somewhat variable, but usually with the first three segments yellow and the remaining segments black---perplexus Cress.
- Third antennal segment shorter than the fifth; occiput usually with black hairs dominating; malar space longer than its width at apex; first five dorsal abdominal segments yellow, remaining two segments black-----fervidus, subsp. dorsalis Cress.
15. Occiput with yellow pubescence dominant; usually a large amount of dirty white or pale yellow pubescence above the bases of the antennae; middle anterior area of the clypeus bare and glossy, with a few hairs on its anterior portion; yellow pubescence of the thorax and the abdomen a tawny yellow----- borealis Kirby.
- Occiput with black pubescence dominant; pubescence about the bases of the antennae black, or with black and light gray hairs intermixed; clypeus nearly covered over with pubescence; the yellow pubescence of the thorax and the abdomen more of a bright lemon yellow-----16.
16. Black band between the bases of the wings usually narrow and distinct; scutellum usually well covered over with yellow pubescence; first five dorsal abdominal segments yellow, the two apical segments black; yellow pubescence usually lemon yellow in color; size medium (22-34 mm.)-----

fervidus Fabr.

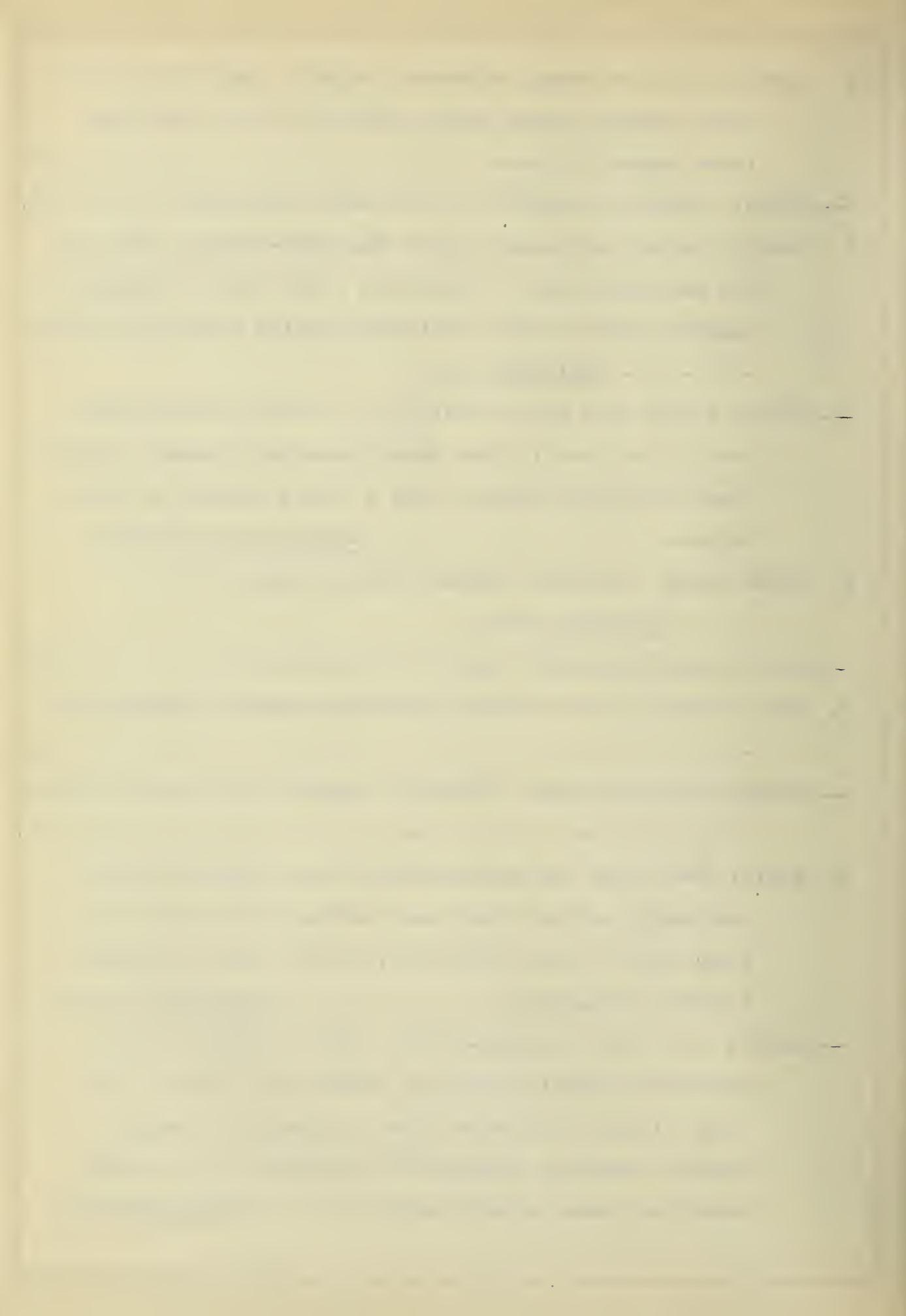
- Black band between the bases of the wings more or less indistinct; scutellum usually with a large amount of black pubescence; first four dorsal abdominal segments usually entirely yellow; apical segments black, yellow, ferruginous or with combinations of these three colors; pubescence more or less dull yellow in color; size large (34-44 mm.) pennsylvanicus DeGeer.

Key for the Separation of the Queens of the Genus

Bremus from Illinois.

1. Anterior dorsal portion of the thorax yellow, a black band between the bases of the wings; scutellum usually yellow, but sometimes completely dominated by black pubescence-----2.
 — Dorsum of the thorax completely yellow, except for occasional black hairs about the center of the disk-----12.
2. Third, fourth, fifth and sixth dorsal abdominal segments black -----3.
 — Third, fourth, fifth and sixth dorsal abdominal segments not entirely black-----4.
3. Occiput of the head bearing black pubescence, or with only a few yellow hairs intermixed; ocelli placed well below the supra-orbital line; second dorsal abdominal segment entirely yellow; of large size (20-28 mm.)-----fraternus F. Sm.
 — Occiput of the head bearing mostly yellowish pubescence; ocelli slightly below the supra-orbital line; second dorsal abdominal segment usually with black on its side margin; of small to medium size (14-16 mm.) ----- rufocinctus Cress.
4. The first four dorsal abdominal segments entirely yellow; fifth and sixth segments black-----5.
 — Dorsal abdominal segments not so colored-----6.
5. Occiput and face with considerable light yellowish pubescence; the middle anterior portion of the clypeus smooth and glossy-----borealis Kirby.
 — Occiput and face with black pubescence; clypeus with middle portion more or less punctate, and as a rule not glossy-----fervidus Fabr.

6. Second and third dorsal abdominal segments entirely yellow,
first segment either yellow, black or both, remaining
three segments black-----7.
- Dorsal abdominal segments not entirely so-colored-----8.
7. Ocelli placed considerably below the supra-orbital line, in
the narrowest part of the front; first dorsal abdominal
segment usually black; scutellum usually with yellow hairs
----- auricomus Robt.
- Ocelli placed near supra-orbital line, above the narrowest
part of the front; first dorsal abdominal segment usually
black; scutellum usually with a strong mixture of black
hairs-----pennsylvanicus DeGeer.
8. First dorsal abdominal segment entirely black-----
-----terricola Kirby.
- First dorsal abdominal segment not so colored-----9.
9. Both second and third dorsal abdominal segments ferruginous--
-----10.
- Second and third dorsal abdominal segments not both ferruginous
-----11.
10. Ocelli just below the supra-orbital line; occiput usually
dominantly yellow; black band between the bases of the
wings more or less indistinct; fourth dorsal abdominal
segment ferruginous -----rufocinctus Cress.
- Ocelli not below the supra-orbital line; occiput usually
dominantly black; black band between the bases of the
wings distinct and broad, with its posterior margin
usually extending backward in the form of a V; fourth
dorsal abdominal segment yellow-----ternarius Say.



11. Last two dorsal abdominal segments with black pubescence dominant; corbicular fringes black-----rufocinctus Cress.
- .Last two dorsal abdominal segments with a light ferruginous pubescence dominant; corbicular fringes with some ferruginous hairs-----frigidus F. Sm.
12. Second dorsal abdominal segment entirely black-----impatiens Cress.
- .Second dorsal abdominal segment not entirely black-----13.
13. First dorsal abdominal segment yellow; second segment, except for a basal middle tawny patch, black; remaining segments black; ocelli placed well below the supra-orbital line-----separatus Cress.
- .Dorsal abdominal segments not so colored; in some species the ocelli not below the supra-orbital line,-----14
14. First four dorsal abdominal segments yellow; fifth and sixth segments black-----fervidus subsp. dorsalis Cress.
- .Dorsal abdominal segments not so colored-----15.
15. Yellow pubescence of the pleura not extending to the bases of the legs-----16.
- .Yellow pubescence of the pleura, at least the mesopleura, extending to the bases of the legs-----18.
16. Malar space longer than its width at lower margin; ocelli placed well below the supra-orbital line; first three dorsal abdominal segments mostly yellow, the remaining segments black-----nevadensis Cress.
- .Malar space not longer than its width at lower margin; ocelli not placed below the supra-orbital line, or only slightly

so; first three dorsal abdominal segments not as above ---

-----18.

17. Ocelli placed near the supra-orbital line, above the narrowest part of the vertex; malar space about as long as its width at lower margin; first two dorsal abdominal segments usually yellow, and the remaining segments black; size medium (15-21 mm) ---- perplexus Cress.

— Ocelli placed just below the supra-orbital line; malar space shorter than its width at lower margin; second and third dorsal abdominal segments usually with some ferruginous pubescence, but the second segment sometimes with a basal median patch of yellow pubescence, the remainder of the segment being black; size small (14-16 mm) --- rufocinctus Cress.

18. First dorsal abdominal segment and a basal median patch of the second segment yellow, remaining segments black-----
bimaculatus Cress.

— Dorsal abdominal segments not so colored-----19.

19. Malar space longer than its width at apex; occiput usually with yellow pubescence dominant; sixth dorsal abdominal segment always black-----vagans F. Sm.

— Malar space at the most not longer than its width at apex; occiput usually with dark pubescence dominating; sixth dorsal abdominal segment sometimes rusty colored at its tip-----affinis Cress.

Key for the Separation of the Workers of the Genus

Bremus from Illinois.

1. Anterior dorsal portion of the thorax yellow; a black band between the bases of the wings; scutellum usually yellow, but sometimes completely dominated by black pubescence-----2.
- Dorsum of the thorax completely yellow, except for occasional black hairs about the center of the disk-----13.
2. Third, fourth, fifth and sixth dorsal abdominal segments with black pubescence-----3.
- Third, fourth, fifth and sixth dorsal abdominal segments not entirely black-----5.
3. First dorsal abdominal segment with yellow pubescence; second segment brown-ferruginous, except the sides and the ^aapical portions, which are yellow; remaining segments mainly black-----affinis Cress.
- Dorsal abdominal segments not so colored-----4.
4. Occiput bearing black pubescence, or with only a few yellow hairs intermixed; ocelli placed well below the supra-orbital line; second dorsal abdominal segment entirely yellow; medium to large size (13-22 mm.)-----fraternus F. Sm.
- Occiput bearing mostly yellowish pubescence; ocelli not well below the supra-orbital line; second dorsal abdominal segment usually with side margins black; small size (7-14mm)-----rufocinctus Cress.
5. First four dorsal abdominal segments entirely yellow; fifth and sixth segments black-----6.
- Dorsal abdominal segments not so-colored-----7.

6. Occiput and face with considerable light yellowish pubescence;
the middle anterior portion of the clypeus smooth and glossy
-----borealis Kirby.
- Occiput and face with black pubescence; clypeus with its middle
anterior portion more or less punctate and as a rule not
glossy---- fervidus Fabr.
7. Second and third dorsal abdominal segments entirely yellow;
first segment yellow, black or both; remaining segments
black-----8.
- Dorsal abdominal segments not entirely so colored-----9.
8. Ocelli placed considerably below the supra-orbital line, in
the narrowest part of the front; first dorsal abdominal
segment usually black; scutellum usually with yellow hairs-
-----auricomus Robt.
- Ocelli placed near the supra-orbital line, above the narrowest
part of the front; first dorsal abdominal segment usually
black; scutellum usually with a strong mixture of black
hairs-----pennsylvanicus DeGeer.
9. First dorsal abdominal segment entirely black; apical segment
whitish ----- terricola Kirby.
- First dorsal abdominal segment not so colored-----10.
10. Both second and third dorsal abdominal segments ferruginous---
-----11.
- Second and third dorsal abdominal segments not both ferruginous
-----12.
11. Ocelli just below the supra-orbital line; occiput usually
dominantly yellow; black band between the bases of the
wings more or less indistinct; fourth dorsal abdominal
segment with pubescence ferruginous----rufocinctus Cress.

- Ocelli not placed below the supra-orbital line; occiput usually dominantly black; black band between the bases of the wings distinct and broad, with its posterior margin extending backward in the form of a V; fourth dorsal abdominal segment with pubescence yellow -----ternarius Say.
- 12. Last two dorsal abdominal segments with black pubescence dominant; corbicular fringes black----- rufocinctus Cress.
- Last two dorsal abdominal segments with light ferruginous pubescence dominant; corbicular fringes with some ferruginous hairs-----frigidus F.Sm.
- 13. Second dorsal abdominal segment entirely black----impatiens Cress.
- Second dorsal abdominal segment not entirely black-----14
- 14. First dorsal abdominal segment yellow; second segment, except for a basal medial tawny patch, black; remaining segments black; ocelli placed well below the supra-orbital line-----separatus Cress.
- Dorsal abdominal segments not so-colored; in some species the ocelli not below the supra-orbital line-----15
- 15. First four dorsal abdominal segments yellow; fifth and sixth segments black-----fervidus subsp. dorsalis Cress.
- Dorsal abdominal segments not so colored-----16
- 16. Yellow pubescence of the pleura not extending to the bases of the legs-----17
- Yellow pubescence of the pleura, at least the mesopleura, extending to the bases of the legs-----19
- 17. Malar space longer than its width at lower margin; ocelli placed well below the supra-orbital line; first three dorsal abdominal segments mostly yellow; the remaining

segments black -----nevadensis Cress.

- Malar space not longer than its width at lower margin; ocelli not placed below the supra-orbital line or only slightly so; first three dorsal abdominal segments not as above---

-----18.

18. Ocelli placed near the supra-orbital line, above the narrowest part of the vertex; malar space about as long as its width at lower margin; first two dorsal abdominal segments usually yellow, and the remaining segments black-----

-----perplexus Cress.

- Ocelli placed just above the supra-orbital line; malar space shorter than its width at lower margin; second and third dorsal abdominal segments usually with some ferruginous pubescence, but the second segment sometimes with a basal middle patch of yellow pubescence, the remainder of the segment being black-----rufocinctus Cress.

19. First dorsal abdominal segment and a medial basal patch of the second segment yellow, remaining segments black-----

-----bimaculatus Cress.

- Dorsal abdominal segments not so-colored-----^{20.}18.

20. First two dorsal abdominal segments yellow-----vagans F. Sm.

- First dorsal abdominal segment yellow, second segment with ferruginous and yellow pubescence-----affinis Cress.

1. The first part of the document is a letter from the President of the United States to the Congress, dated January 3, 1801. It contains a report on the state of the Union and the progress of the government during the year 1800. The letter is signed by James Madison.

2. The second part of the document is a report from the Secretary of the Treasury, dated January 3, 1801. It contains a detailed account of the financial state of the government and the progress of the Treasury during the year 1800. The report is signed by Alexander Hamilton.

3. The third part of the document is a report from the Secretary of the Navy, dated January 3, 1801. It contains a detailed account of the naval operations of the government and the progress of the Navy during the year 1800. The report is signed by John Adams.

4. The fourth part of the document is a report from the Secretary of the War, dated January 3, 1801. It contains a detailed account of the military operations of the government and the progress of the War during the year 1800. The report is signed by Henry Knox.

5. The fifth part of the document is a report from the Secretary of the Interior, dated January 3, 1801. It contains a detailed account of the land and mineral resources of the United States and the progress of the Interior during the year 1800. The report is signed by Thomas Mifflin.

6. The sixth part of the document is a report from the Secretary of the Agriculture, dated January 3, 1801. It contains a detailed account of the agricultural operations of the government and the progress of the Agriculture during the year 1800. The report is signed by Robert Morris.

7. The seventh part of the document is a report from the Secretary of the Commerce, dated January 3, 1801. It contains a detailed account of the commercial operations of the government and the progress of the Commerce during the year 1800. The report is signed by John Jay.

8. The eighth part of the document is a report from the Secretary of the Education, dated January 3, 1801. It contains a detailed account of the educational operations of the government and the progress of the Education during the year 1800. The report is signed by Thomas Jefferson.

9. The ninth part of the document is a report from the Secretary of the Religion, dated January 3, 1801. It contains a detailed account of the religious operations of the government and the progress of the Religion during the year 1800. The report is signed by James Madison.

10. The tenth part of the document is a report from the Secretary of the Arts, dated January 3, 1801. It contains a detailed account of the artistic operations of the government and the progress of the Arts during the year 1800. The report is signed by Thomas Jefferson.

Key for the Separation of the Males of the Genus
Psithyrus from Illinois.

1. Yellow pubescence of the thorax extending down on the pleura
to the bases of the legs-----2.
- Yellow pubescence of the thorax not extending down on the pleura
to the bases of the legs-----3.
2. Fourth dorsal abdominal segment bearing black pubescence-----
-----laboriosus Fabr.
- Fourth dorsal abdominal segment bearing yellow pubescence-----
---insularis F.Sm. (= consultus Frank.)
3. First dorsal abdominal segment bearing mostly black pubescence;
fifth antennal segment longer than the third segment-----
-----variabilis Cress.
- First dorsal abdominal segment bearing mostly yellow pubescence;
fifth antennal segment no longer than the third segment---
-----ashtoni (Cress.) D.T.

Key for the Separation of the Queens of the Genus

Psithyrus from Illinois.

1. Occiput of the head bearing mostly black pubescence-----
-----ashtoni Cress.
- Occiput of the head bearing mostly yellow pubescence-----2.
2. Yellow pubescence of the thorax not extending far below the
bases of the wings-----variabilis Cress.
- Yellow pubescence of the thorax extending well down on the
pleura-----3.
3. Dorsum of the thorax yellow, except for occasional black hairs
about the center of the disk; usually with some yellow
between the eyes-----laboriosus Fabr.
- Dorsum of the thorax with more or less of an indistinct band
between the bases of the wings, or a large number of black
hairs about the disk; usually with considerable yellow
pubescence on the upper half of the space between the eyes
-----insularis F. Sm.

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Explanation of Figures.

- Fig. 1. Ideal situation for B. pennsylvanicus nests in grass-grown field near Champaign, Illinois.
- Fig. 2. Timber-edge at White Heath, Illinois, where nest of B. pennsylvanicus was taken.
- Fig. 3. Bridge near White Heath, Illinois, where a domicile buried in the bank near one end of the trestle work was occupied by a queen of B. auricomus. The year before, a nest of B. pennsylvanicus was removed from the same situation.
- Fig. 4. Rock-pile, such as is common near Canton, New York, from which a nest of B. fervidus was removed.
- Fig. 5. A domicile placed in the ground in the woods near the log shown in picture furnished a colony of B. bimaculatus. (Urbana, Illinois.)
- Fig. 6. A domicile located in this stump in the woods was occupied by a queen of B. bimaculatus. (Urbana, Illinois).
- Fig. 7. Domicile- Type A. First type employed to attract the queens of Dromus.
- Fig. 8. Domicile - Type B. used in the spring of 1916 for attracting queens.
- Fig. 9. Domicile - Type C adopted in 1917 for attracting queens.
- Fig. 10. Map of the approximate distribution of B. terricola.
- Fig. 11. Map of the approximate distribution of B. borealis.
- Fig. 12. Map of the approximate distribution of B. bimaculatus.
- Fig. 13. Map of the approximate distribution of B. impatiens.
- Fig. 14. Map of the approximate distribution of B. vagans.
- Fig. 15. Map of the approximate distribution of B. perplexus.

Fig. 16. Map of the approximate distribution of P. frigidus.

Fig. 17. Map of the approximate distribution of P. pennsylvanicus.

Fig. 18. Map of the approximate distribution of P. fervidus.

Fig. 19. Map of the approximate distribution of P. auricomus.

Fig. 20. Map of the approximate distribution of P. separatus.

Fig. 21. Map of the approximate distribution of P. fraternus.

Fig. 22. Map of the approximate distribution of Ps. laboriosus.

Fig. 23. Map of the approximate distribution of Ps. variabilis.

*Fig. 1**Fig. 2**Fig. 3*



Fig. 4



Fig. 5



Fig. 6

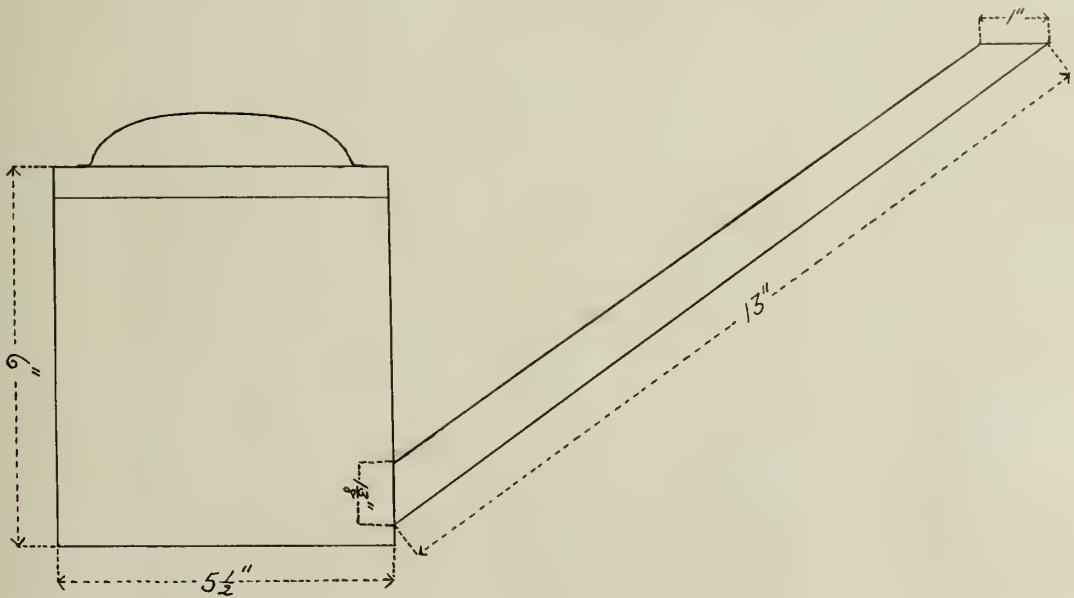


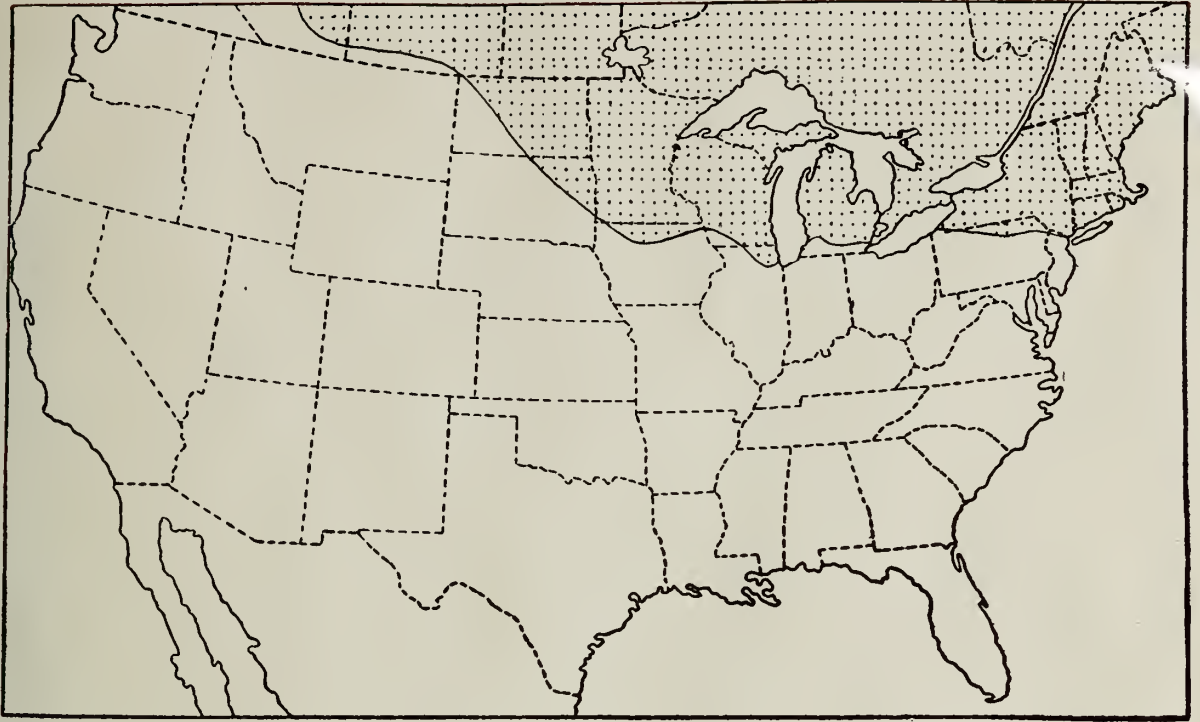
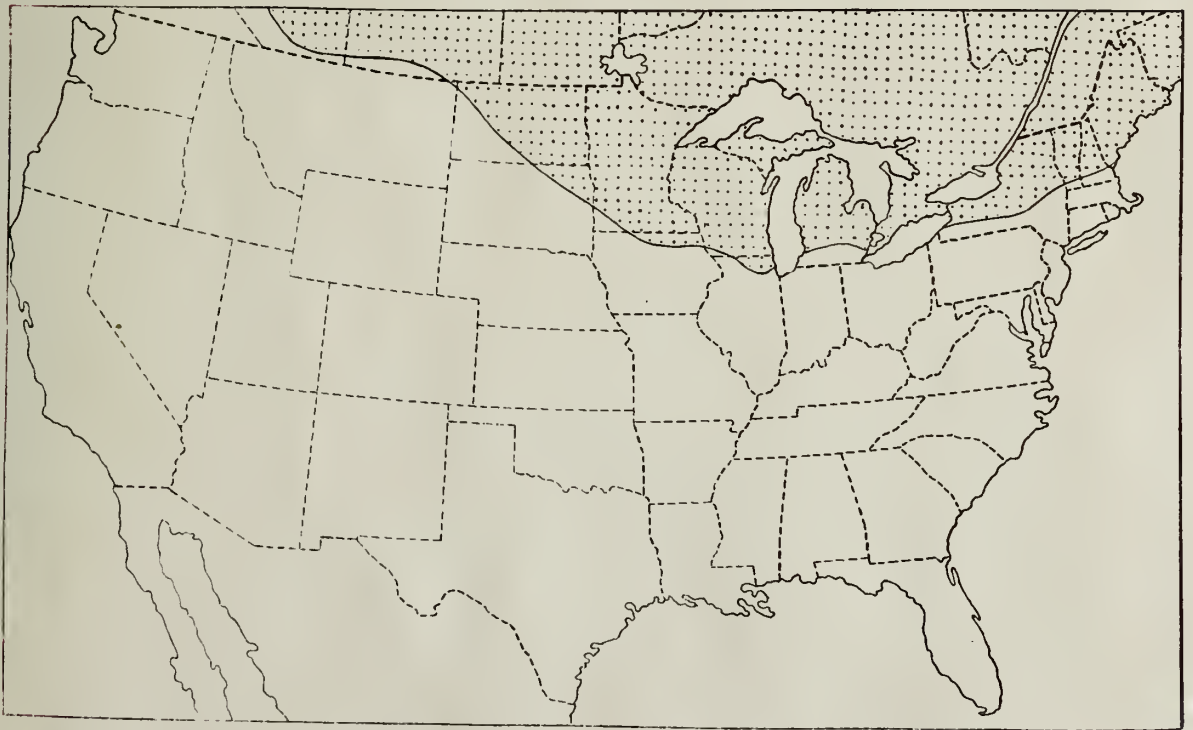
Fig. 7. Domicile Type A.

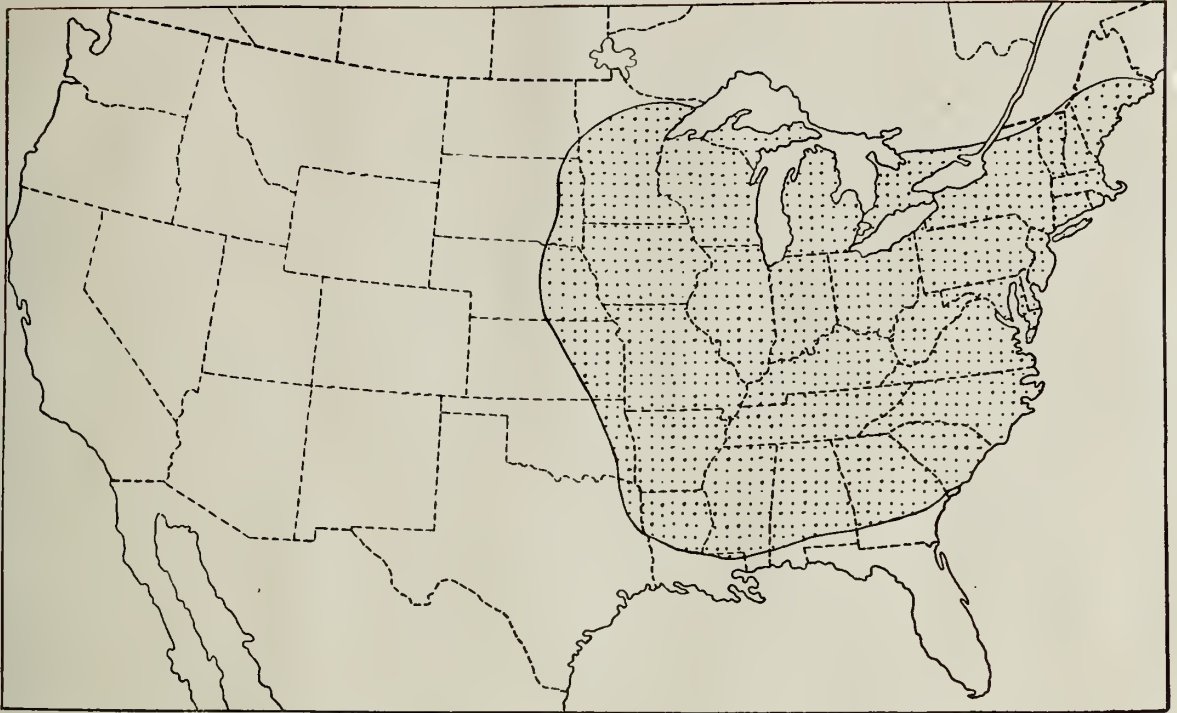
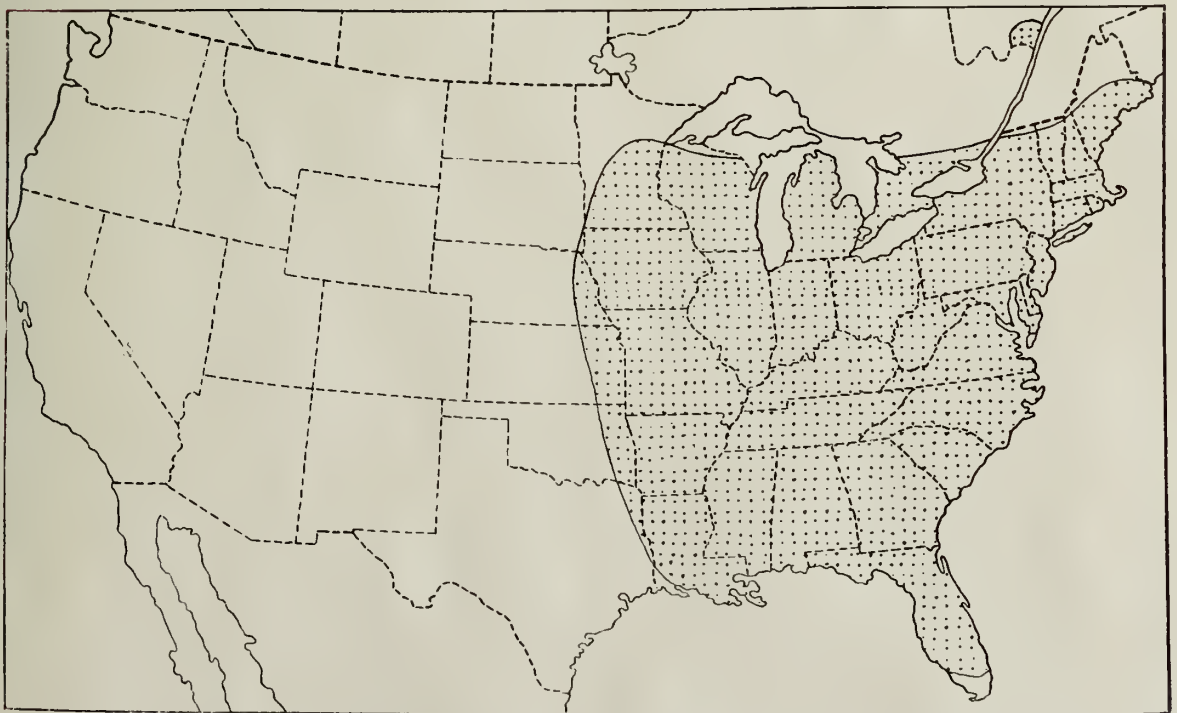
Fig. 7

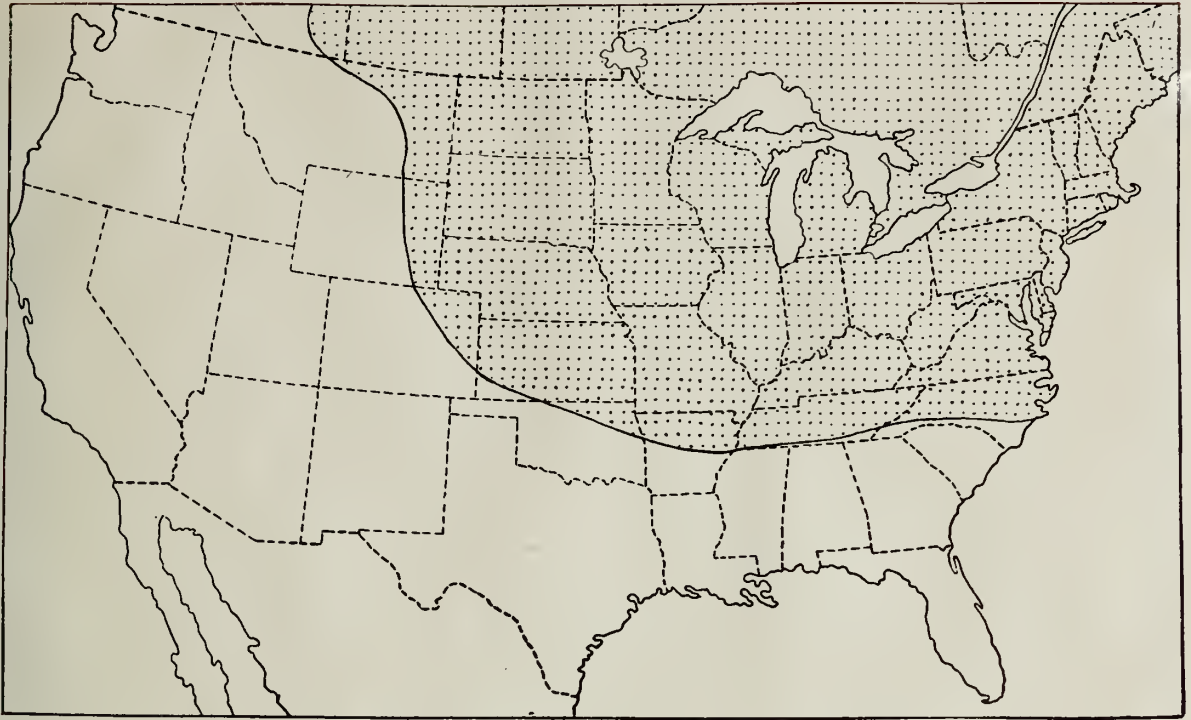
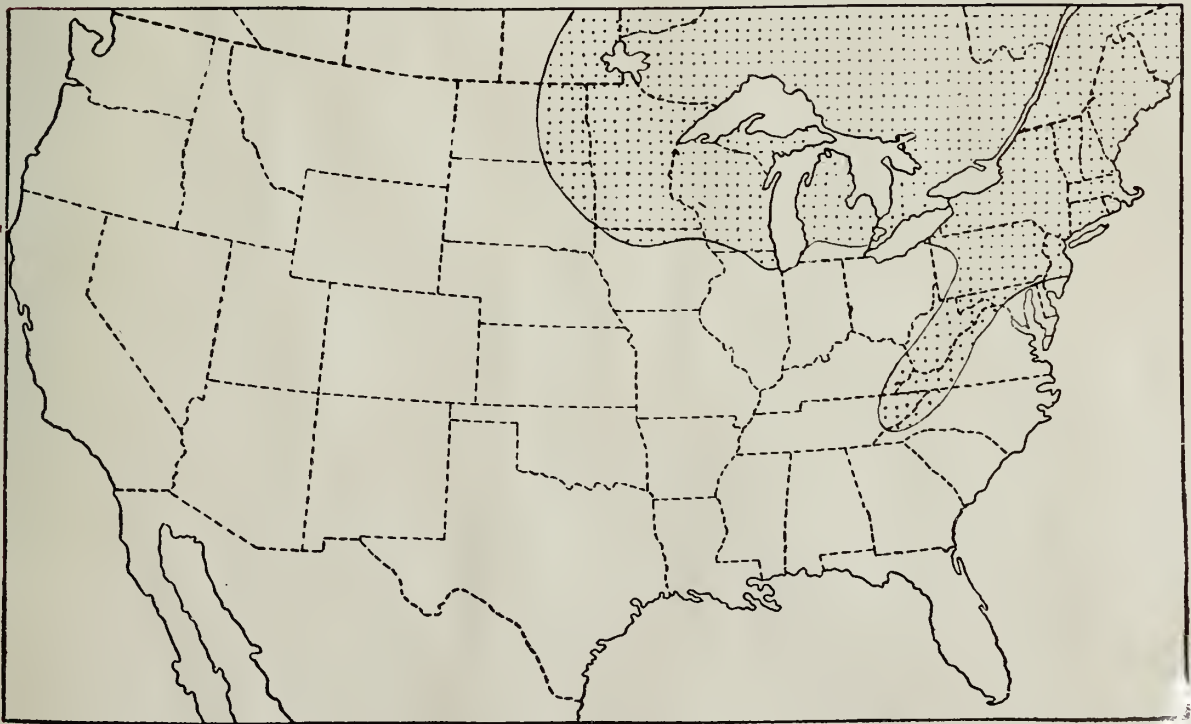


Fig. 8

*Fig. 9*

*Fig. 10**Fig. 11*

*Fig. 12**Fig. 13*

*Fig. 14**Fig. 15*

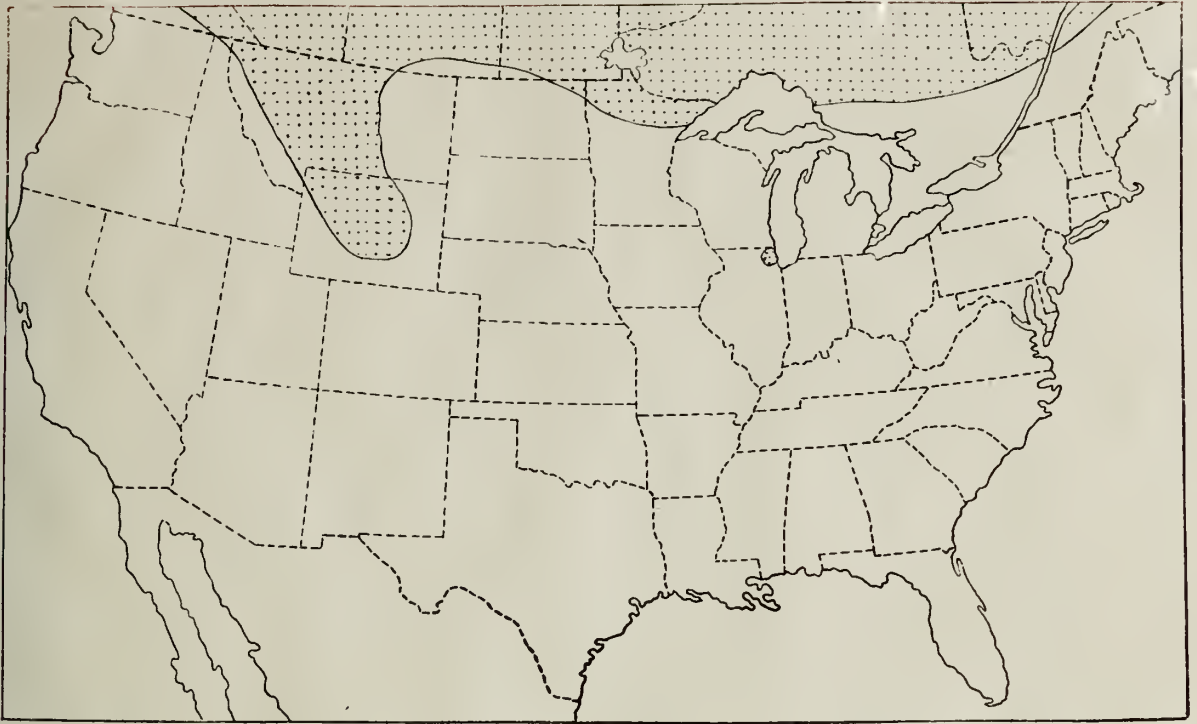


Fig. 16

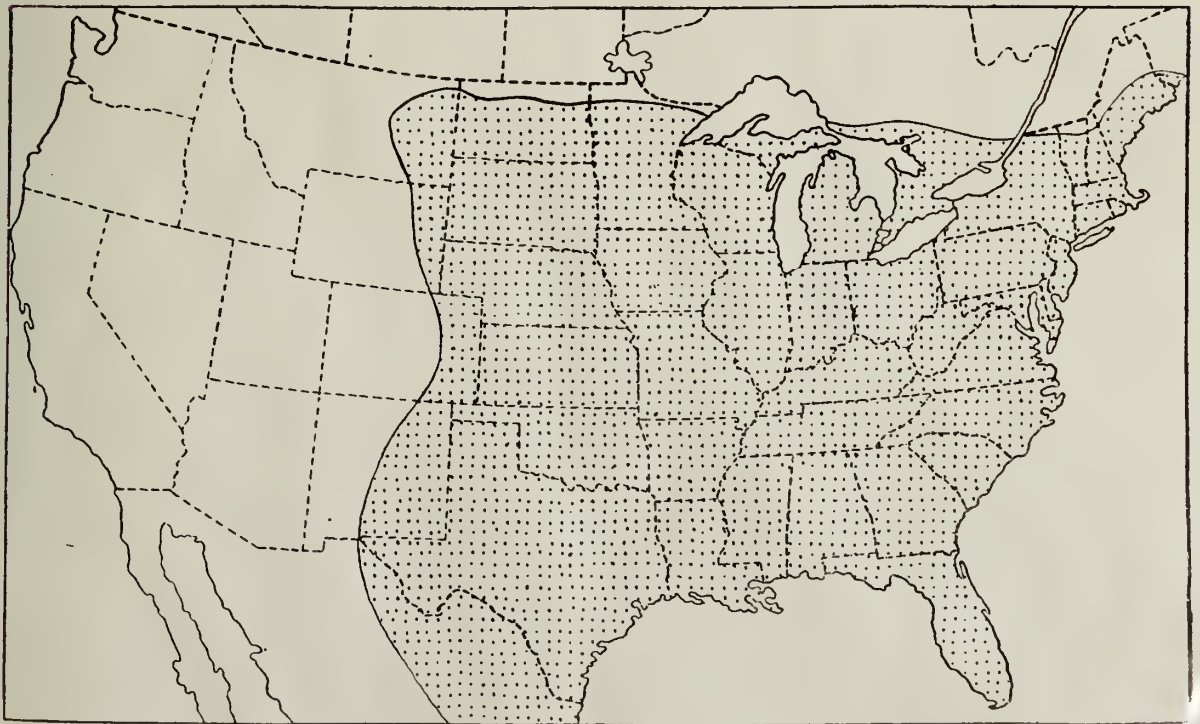
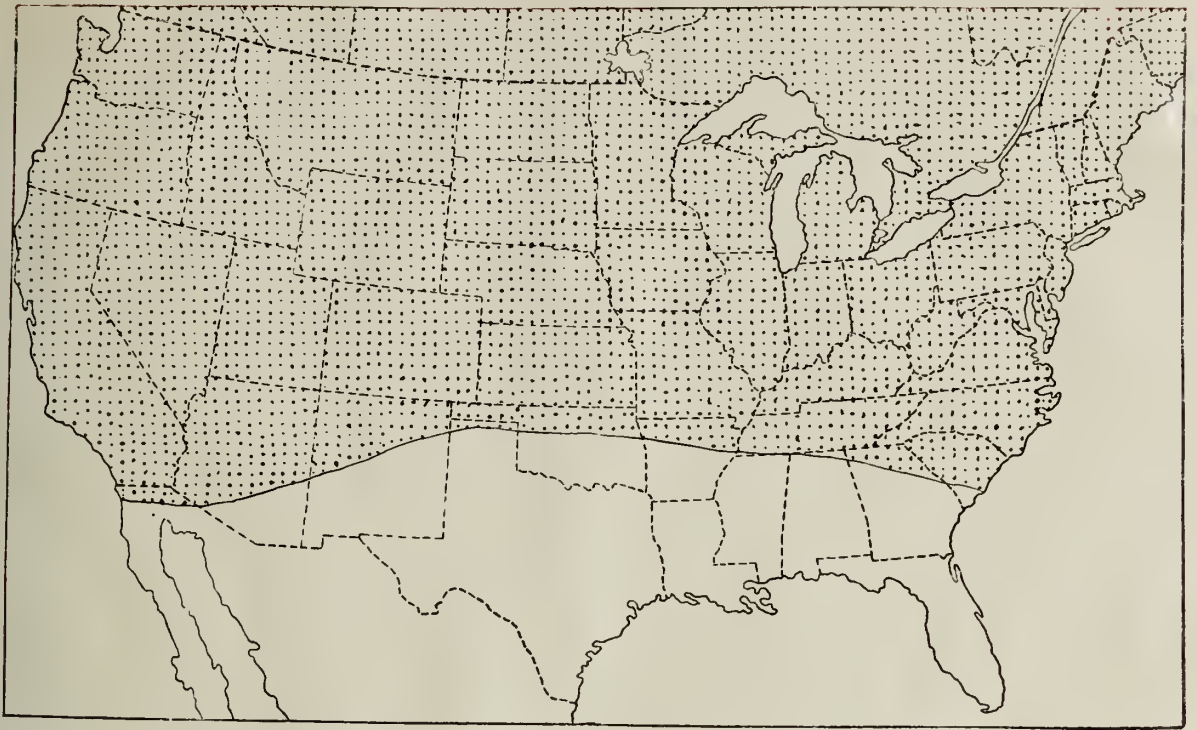
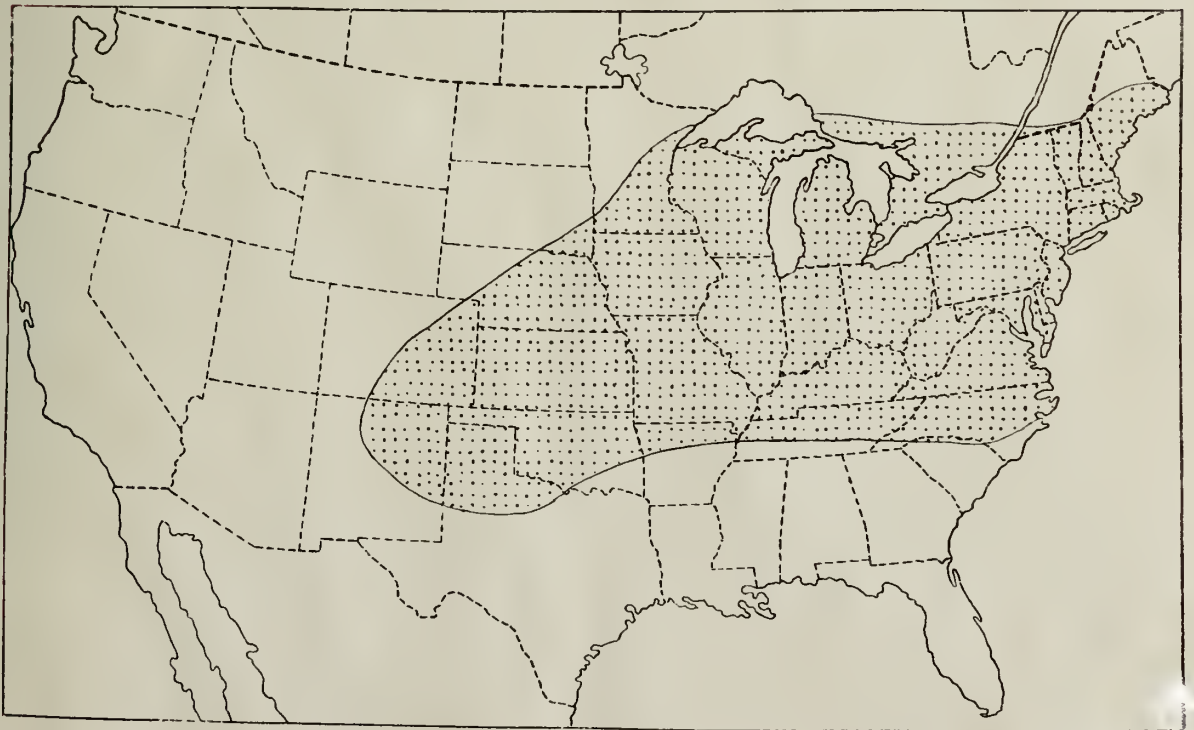


Fig. 17

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*Fig. 18**Fig. 19*

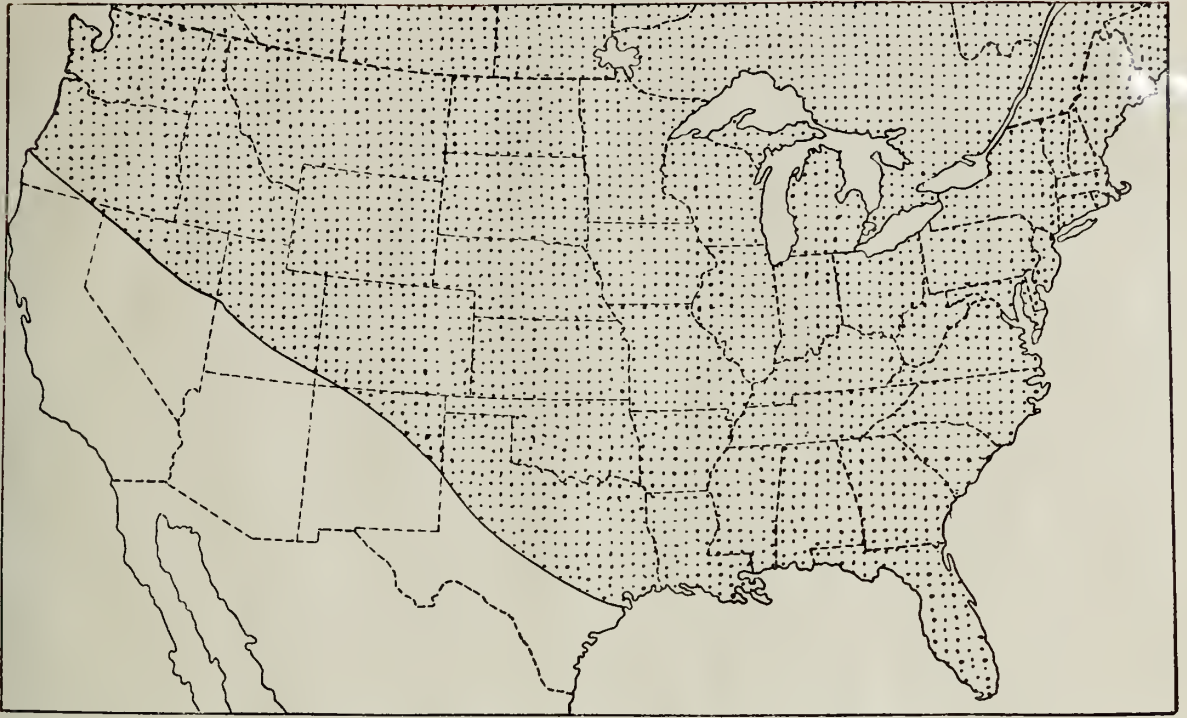
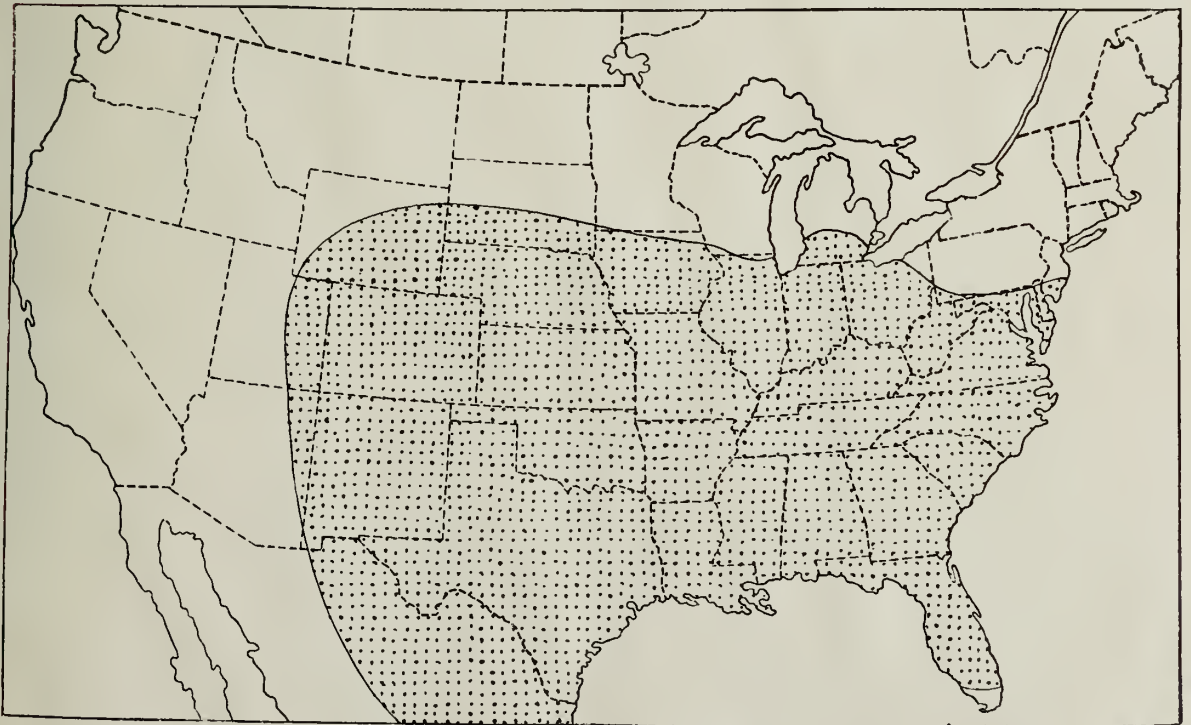
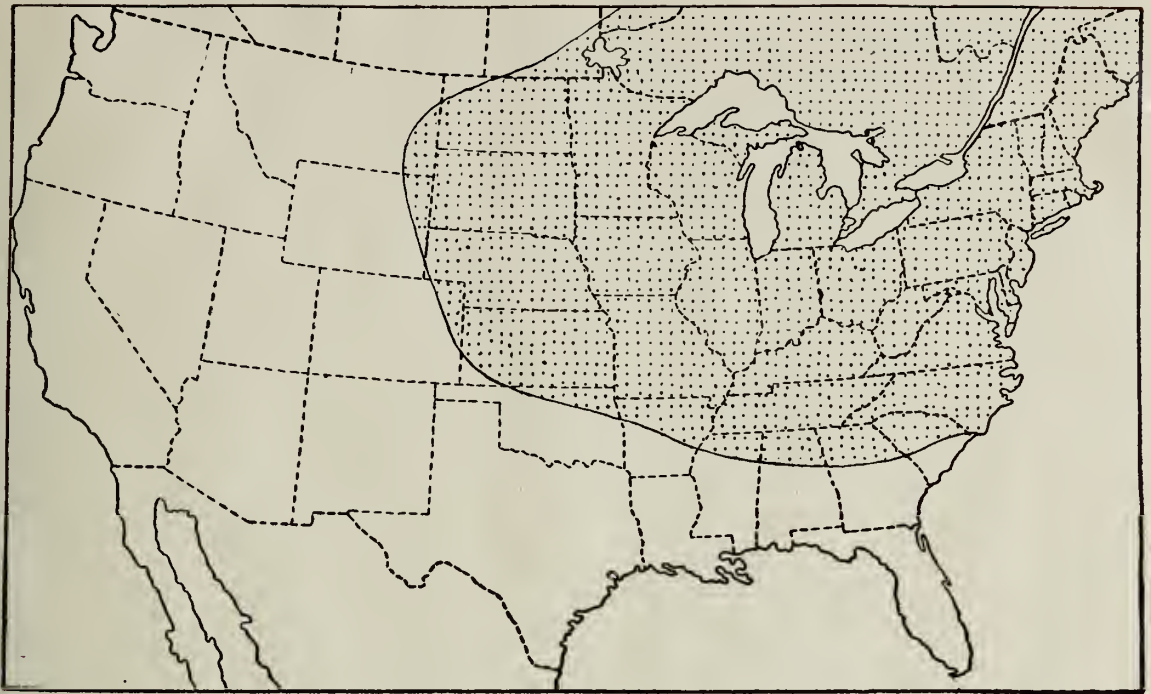
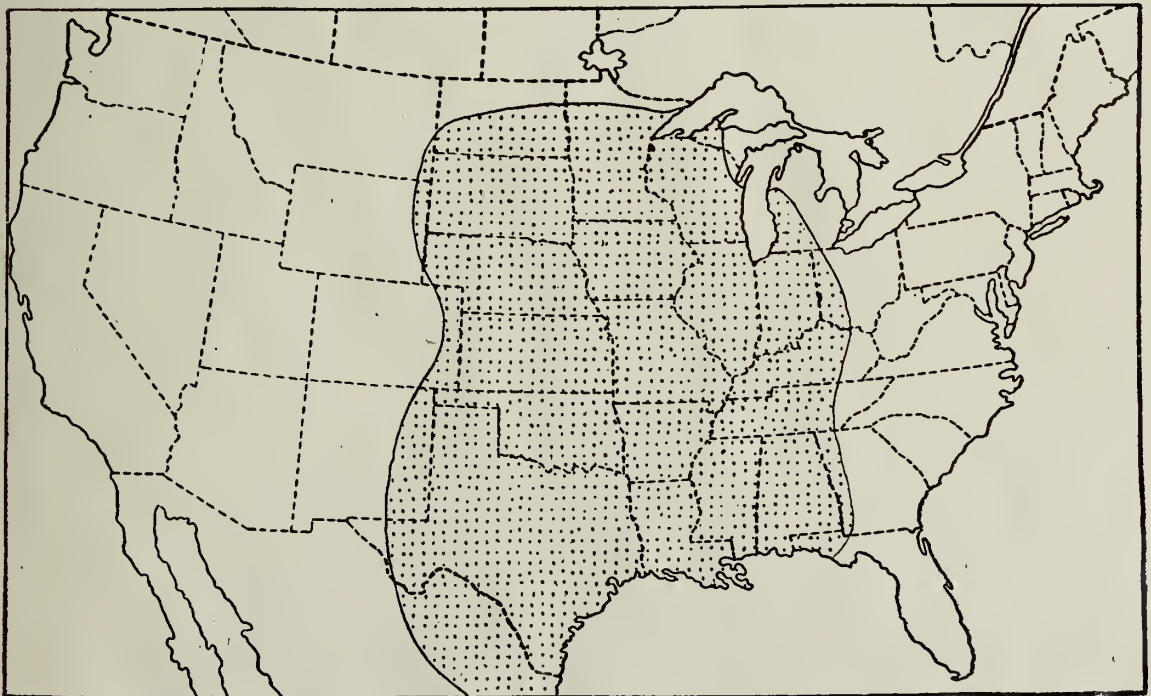


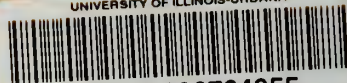
Fig. 20



*Fig. 22**Fig. 23*

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